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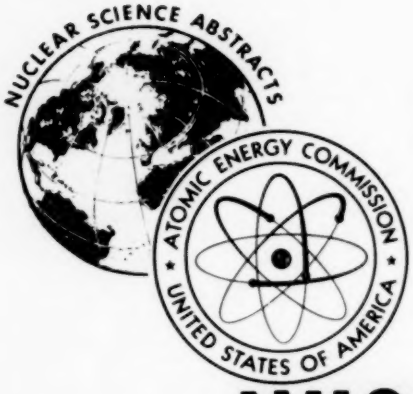


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# NUCLEAR SCIENCE ABSTRACTS

Volume 17 Number 7

Abstracts 10238–12054

April 15, 1963

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Volume 17, Number 7, April 15, 1963

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# TABLE OF CONTENTS

Volume 17, Number 7, April 15, 1963


| Category | Page |
|---|---|
| GENERAL AND MISCELLANEOUS | 1321 |
| BIOLOGY AND MEDICINE | 1324 |
| General and Miscellaneous | 1324 |
| Biochemistry, Nutrition, and Toxicology | 1329 |
| Radiation Effects on Living Tissues | 1337 |
| Radiation Sickness | 1358 |
| CHEMISTRY | 1362 |
| General and Miscellaneous | 1362 |
| Analytical Procedures | 1367 |
| Inorganic and Physical Chemistry | 1372 |
| Organic Chemistry | 1383 |
| Radiation Chemistry and Radiochemistry | 1384 |
| Raw Materials and Feed Materials | 1391 |
| Separation Processes | 1392 |
| ENGINEERING AND EQUIPMENT | 1400 |
| General and Miscellaneous | 1400 |
| Heat Transfer and Fluid Flow | 1401 |
| Materials Testing | 1405 |
| GEOLOGY, MINERALOGY, AND METEOROLOGY | 1407 |
| HEALTH AND SAFETY | 1410 |
| INDUSTRIAL APPLICATIONS OF ISOTOPES AND RADIATIONS | 1416 |
| INSTRUMENTS AND INSTRUMENTATION | 1418 |
| General and Miscellaneous | 1418 |
| Radiation Detection | 1430 |
| ISOTOPE SEPARATION | 1436 |
| MATHEMATICS AND COMPUTERS | 1438 |
| METALS, CERAMICS, AND OTHER MATERIALS | 1440 |
| General and Miscellaneous | 1440 |
| Corrosion | 1447 |
| Fabrication | 1448 |
| Properties and Structure | 1453 |
| Radiation Effects | 1463 |
| PHYSICS | 1469 |
| General and Miscellaneous | 1469 |
| Astrophysics and Cosmology | 1489 |
| Cosmic Radiation | 1489 |
| Criticality Studies | 1490 |
| Elementary Particles and Radiations | 1491 |
| Neutron Physics | 1505 |
| Nuclear Properties and Reactions | 1508 |
| Particle Accelerators | 1527 |
| Plasma Physics and Thermonuclear Processes | 1534 |
| Shielding | 1543 |
| Theoretical Physics | 1544 |
| REACTOR TECHNOLOGY | 1548 |
| General and Miscellaneous | 1548 |
| Power Reactors | 1553 |
| Production Reactors | 1559 |
| Research Reactors | 1559 |
| SPACE APPLICATIONS AND TECHNOLOGY | 1561 |
| WASTE DISPOSAL AND PROCESSING | 1563 |
| CORPORATE AUTHOR INDEX | INDEX-1 |
| PERSONAL AUTHOR INDEX | INDEX-12 |
| SUBJECT INDEX | INDEX-48 |
| REPORT NUMBER INDEX | INDEX-114 |

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Volume 17, Number 7 April 15, 1963

# NUCLEAR SCIENCE ABSTRACTS

## GENERAL AND MISCELLANEOUS

**10238** (AD-278378) ANALYSES AND EVALUATION OF SEISMIC DATA FOR ON SITE INSPECTION. Semi-annual Summary Report, [January 30–June 30, 1962]. (Beers (Roland F.), Alexandria, Va.). July 12, 1962. Project VELA. Contract AF33(600)-43368. 57p.

On-site cavity location data from the Nevada Test Site and Tatum Salt Dome, Mississippi, are presented in graphical form. The data are the near-surface velocity, uphole velocity, and horizontal ranging seismic records observed on the surface near the Rainier, Blanca, Logan, and Lollipop nuclear test sites and special split spread reflection records shot across the Tatum Salt Dome. The effects of the nuclear tests on surface amplitudes and first arrival times were studied, and the Tatum Salt Dome data are interpreted. Preliminary studies of the horizontal seismic ranging method are reported. (D.L.C.)

**10239** (MLM-1140) MOUND LABORATORY PROGRESS REPORT FOR AUGUST 1962. G. R. Grove, L. V. Jones, and J. F. Eichelberger (Mound Lab., Miamisburg, Ohio). Aug. 30, 1962. Contract AT(33-1)-Gen-53. 25p.

The need for more shock resistant thermosetting plastics led to the development of glass-filled diallyl phthalate as a molding powder. The glass-filled formulation has a greater shock resistance than the asbestos-filled plastic. The molding characteristics of the glass-filled material were very good, but a new technique for inspection is required, since bright spots on the x ray films from the orientation of the glass fibers appeared as high density inclusions. The effect of the initial curve temperature on Oxiron adhesives is being studied. By properly controlling the initial curve temperature, increased tensile strength at 160°F can be obtained without imparing the flexibility of the material. When the ratio of anhydride to epoxy is too small for a satisfactory cure, increased initial cure temperatures do not cause an increase in tensile strength at 160°F. A system to determine the thermomolecular correction for $He^3$ vapor pressure data is being assembled. This research is directed toward establishing an international temperature scale between 0.3 and 3.2°K. The isotopes of B may be separated by thermal diffusion if $BF_3$ is used as the feed gas. Thermodynamic studies revealed that most conventional materials of construction are stable in $BF_3$ up to 1000°K. Methane is being evaluated as a feed gas to separate $C^{13}$ by thermal diffusion. A hot-wire thermal diffusion column separates the heavy impurities in $CH_4$ prior to enrichment of the $C^{13}$. Low temperature distillation is also being evaluated as a technique to separate the impurities from $CH_4$. Studies on the conversion of CO to $CH_4$ with the activated Ni catalyst are being continued. Alternate methods to separate U isotopes are being evaluated. The reaction of $UF_6$ at elevated temperatures with various materials is being studied. Thermodynamic calculations indicate that Au is the only material which is stable in $UF_6$ at elevated temperatures. This material may be used in the design of a thermal diffusion column to separate research quantities of the U isotopes. The separation of $U^{234}$ from aged $Pu^{238}$ was demonstrated. Preliminary calculations indicate that Pu elution is not always quantitative. An agglomeration and degradation of the resin from alpha bombardment may contribute to poor elution. Although the total capacity of the experimental resin was greatly reduced, no accurate figures are available. New compounds of Po are being developed for use in lunar probe space vehicles. The polonides of all the rare earths (except Pm, Y, and Sm) were prepared. The melting points of these polonides varied from 1370°C for Tb to 2400°C for Yb. The half-lives of three $Ac^{227}$ samples, determined in various calorimeters over an eight-year period, were calculated to be 21.771 years with a probable error of less than one day. These samples will be used as secondary heat standards in calorimetry. The viscosity of liquid Pr was remeasured at six different temperatures from 934 to 1009°C in an oxcillating cup viscosimeter to check the results of previous determinations. The results were in agreement with those previously obtained. Viscosity measurements were made at 936 to 1009°C. These data are still being evaluated. A method is being developed to measure the interfacial tensions of liquid metals. Although the maximum bubble pressure method is satisfactory for measurements involving aqueous-organic solutions, it is not satisfactory for liquid metals. Metallographic examination of Pu–Y alloys indicates a solid solubility betwen 20 and 22.5 at.% Pu in Y with no solid solubility of Y in Pu. The single phase, solid solution Y alloy has possibilities as a potential high temperature fuel material. Metallographic analysis of a Y crucible which contained molten U metal showed a solution attack of the Y by the U. The presence of an immiscible layer and droplets of a U–Y solution indicates that a miscibility gap is present in the system with the monotectic temperature below 1200°C. The results indicate that high purity Y is not an acceptable container for molten U. The Pu–Ce–Cu ternary system is being investigated as a potential fuel system for the molten Pu fast breeder reactor concept. The results of phase studies by metallography and differential thermal analysis continue to support the locations of the ternary eutectics and primary phase fields as previously defined. The epsilon to delta Pu phase transformation was found to occur on the liquidus surface in the Pu primary phase field of the ter-

nary system. In the Pu–Ce binary system, this transformation occurs in the solid state. However, the addition of Cu sufficiently reduces the temperature of the liquidus surface so that the transformation occurs in liquid. A mechanism for the introduction of fine powders in the induction coupled plasma torch was designed and used successfully. Introduction of less than 37 $\mu$ 90% $PuO_2$–10% $UO_2$ powder into the plasma flame by the new mechanism resulted in complete spheroidization. (auth)

**10240** (NP-12208) JAARVERSLAGEN, 1961. (Progress Report for 1961). (Stichting Voor Fundamenteel Onderzoek der Materie, Utrecht and Stichting Instituut Voor Kernphysisch Onderzoek, Amsterdam). 162p.

Administrative and financial statements for both institutions are included. The work done on nuclear physics, mass separation and analysis, metallurgy, molecular physics, solid-state physics, thermonuclear reactions, and particle accelerators is reported. (J.S.R.)

**10241** (NP-12324) COMMISSARIAT A L'ENERGIE ATOMIQUE RAPPORT ANNUEL, 1961. (Annual Report of Commissariat a l'Energie Atomique, 1961). (France. Commissariat a l'Energie Atomique, Paris). 169p.

The annual report of the CEA gives a survey of its activities with only an indication of the results of particular studies. The general structure and finances of the CEA are given. The activities summarized are the production of basic materials of nuclear industry, technological and scientific investigation (general physics, reactor physics, nuclear fuels, nuclear materials, chemistry, biology, health physics, and mineralogy), reactors, artificial radioelements, relations of the CEA with industry, international and public relationships, and teaching and training. The organization and composition of committees and consultive commissions are given. (J.S.R.)

**10242** (NP-12339) CIMARRON. Job Assignment 10-62. LRSM Revised Preliminary Report [of] Project VT/074. (Geotechnical Corp., Garland, Tex). June 15, 1962. Contract AF33(600)-41694. 60p.

An extension and revision of data previously presented in a preliminary report on CIMARRON are presented. The principal phases generated by aftershock were analyzed, and the travel times and amplitudes were compared with those associated with the event itself. Data were obtained from magnetic-tape playback and films of long-range seismic measurements. (J.R.D.)

**10243** (NP-12381) ANNUAL REPORT NO. 4, MARCH 1961 TO FEBRUARY 1962. (New Zealand. Inst. of Nuclear Sciences, Lower Hutt). Mar. 1962. 124p.

A summary of work during the period March 1961 to February 1962 is presented. The $C^{14}$ duplication equipment was installed and is in operation for $C^{14}$ ages, and the cosmic ray equipment is functioning well. Other information is included concerning research on various $C^{14}$ measurements, $C^{13}$ variations in nature, well-logging, tritium age measurements, fallout, Ar–K age measurements, radiation effects on liquid $H_2S$ systems, counting equipment development, and administrative matters. (J.R.D.)

**10244** (NP-12444) STILLWATER. LRSM Final Report. Job Assignment 5-62. (Geotechnical Corp., Garland, Tex.). June 15, 1962. Contract AF33(600)-41694. 109p.

Data are presented in both tabular and graphic forms for the travel times and amplitudes of the principal seismic phases generated by the STILLWATER detonation in Nevada. The data are from 25 LRSM stations in various parts of USA. (D.L.C.)

**10245** (NP-12524) MAD. Long Range Seismic Measurements of VELA UNIFORM Project 8.4. (Air Force Technical Applications Center, Washington, D. C.). Dec. 13, 1961. 26p.

An analysis is presented of the LRSM film seismograms of the MAD event from mobile field teams, from the Wichita Mountains Seismological Observatory, and from experimental and temporary stations. (J.R.D.)

**10246** (ORNL-TM-403) QUARTERLY PROGRESS REPORT FOR CHEMICAL DEVELOPMENT SECTION B, JULY–SEPTEMBER 1962. R. E. Blanco (Oak Ridge National Lab., Tenn.). Feb. 7, 1963. Contract [W-7405-eng-26]. 63p.

UC dissolves in $HNO_3$ to give mixtures of soluble organic polycarboxylic acids. A tentative analysis is given for the acids resulting from the dissolution of UC in boiling 4 N $HNO_3$. The reactions of as-cast uranium carbides containing 2 to 10 wt % C with water were studied. The continuous dissolution of 2% U–Zr alloy fuel in a Ti dissolver was demonstrated using as dissolvent refluxing $HNO_3$–HF–$HBF_4$–Cr–Zr. $U^{233}$ was separated from $Th^{228}$ and its daughters by extracting from an acid feed and scrubbing with acid-deficient $Al(NO_3)_3$. The effects of nitrates on the dissolution of $UO_2$ pellets in $HNO_3$ were studied. No boron was leached from glass raschig rings containing 3.8 wt % B by solutions containing U, Th, and $HNO_3$. The Pa concentration of solutions containing Th, $Pa^{231}$, $HNO_3$, Al, and $F^-$ was stable over one month and remained unaffected by contact with stainless steel for 1 week. Removal of Pa from solutions by Vycor glass and silica gel was studied. Tests were run on the size distribution of $UO_2$ fines produced by a miniature hydraulic shear in the cutting unirradiated and irradiated clad $UO_2$. Corrosion studies were carried out for "A" nickel, Haynes 25, and INOR-8 in $N_2$–$CCl_4$ and cyclic $O_2/Cl_2$–$CCl_4$ and for welded stainless steel and Corronel 230 in $HNO_3$–HF. Thermal stability of simulated high-sulfate Purex waste and glass fixations of simulated TBP-25 waste, and the corrosion of stainless steel by Purex waste and a salt mine were studied. The effects of phosphates and $Na_2CO_3$ in a synthetic low-level waste solution on the hardness of the effluent from a laboratory clarifier were studied. The precipitation of Ca and Mg from ORNL low-level waste and the removal of foaming agent from solutions were studied. The vapor pressures of TBP over its TBP–$HNO_3$–$H_2O$ solutions were measured at 25°C. Experiments were made on the head-end precipitation in the laboratory-scale flowsheet for the precipitation-ion exchange method for the recovery of Sr from 1WW Purex waste. The effects of gamma irradiation to a dose of $4.2 \times 10^8$ r on the hydroxyl form of Dowex 1 X-10 were studied under dynamic flow conditions. The partial reduction of $BaSO_4$, $SrSO_4$, $CaSO_4$, and $MgSO_4$ by $H_2$ was studied. (D.L.C.)

**10247** (TID-7638) CONFERENCE ON PROGRESS IN NUCLEAR EDUCATION, GATLINBURG, TENNESSEE, AUGUST 20-22, 1962. (Oak Ridge National Lab., Tenn.; Oak Ridge Inst. of Nuclear Studies, Inc., Tenn.; and American Nuclear Society, Oak Ridge, Tenn.). 190p.

Eighteen papers and two panel discussions are presented on various questions involved in the teaching of nuclear science and engineering. Both graduate and undergraduate programs of study are considered. Advances in secondary-school science education are described. Future needs are discussed. (D.L.C.)

**10248** (UCRL-Pub-42) STATUS REPORT — FISCAL YEAR 1962. (California. Univ., Berkeley. Lawrence Radiation Lab. and California. Univ., Livermore.

Lawrence Radiation Lab.). Contract W-7405-eng-48. 181p.

Information is presented to show in large perspective the research, operational, and support activities required for the extensive research and development program of the Laboratory for fiscal 1962. Sections are included on research projects, research and development methods and administration, service organization functions, cost aspects, and plans for future activities. (J.R.D.)

**10249** (EURAEC-301) THE USE OF PLUTONIUM AS FUEL IN NUCLEAR REACTORS. Quarterly Report No. 2, January 1–March 31, 1962. (Brussels. Centre d'Etude de l'Energie Nucléaire and Société Belge pour l'Industrie Nucléaire, Brussels). Apr. 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 078-61-12RDB. 60p. A translation. (BN-6204-01)

Apparatuses for the out-of-pile thermal simulation of ceramic fuel elements and the study of grain growth of ceramic materials are described. The starting sintering temperature for $UO_{2.20}$ was determined dilatometrically under various atmospheres. The testing of canning tubes, fuel elements, and welds by various methods was studied. The irradiation tests to be carried out on $UO_2$ and $PuO_2$ are described, and the $UO_2$ samples and their irradiation conditions are tabulated. Equipment for the after-irradiation tests is described. (D.L.C.)

**10250** ANALYSIS OF THE COST OF THE NUCLEAR KILOWATT HOUR. J. Gaussens (Commissariat à l'Energie Atomique, [Paris]). Energie Nucl., 4: 311-19(Sept.-Oct. 1962). (In French)

After a comparison of the value of two possible formulas to express the cost of the nuclear kilowatt hour (one considers the price of the kwh produced in a year and the other considers the expenses extending over the supposed life of the nuclear power plant), the elements of the structure of this cost—investments, operating costs, and fuel costs—are studied. The capacities of the industrial segments engaged in nuclear production, their effect on the cost of nuclear energy, and the possibility of predicting, according to their development, the cost evolution of the nuclear kwh are considered. (tr-auth)

**10251** NUCLEAR ENERGY–A COMPETITIVE SOURCE OF ELECTRICITY? Hans Michaelis. Euratom Bull., No. 4, 10-18(1962). (In English)

The need for and economics of nuclear power plants in the European Atomic Energy Community are reviewed. The costs and charges of nuclear and conventional power sources are compared. The status of nuclear power is outlined. (T.F.H.)

**10252** ATOMIC PROPULSION OF SHIPS. Jean-Paul Ricard (Compagnie Générale Translantique, Paris) Ind. At., 6: No. 9-10, 59-68(1962). (In French)

The advantages and disadvantages of the nuclear propulsion of ships are considered both for naval and maritime purposes. The increased range of nuclear ships justifies their use in both submarine and surface naval vessels. However, the economic problems are of importance for merchant ships. The conditions to be realized before the application of nuclear energy to merchant vessels are tabulated. The advantages of nuclear propulsion are indicated, and the different types of reactors proposed for this purpose are considered. The possible future of nuclear propulsion for ships is reviewed. (J.S.R.)

**10253** PRACTICAL APPLICATIONS OF SHORT-LIVED RADIOISOTOPES. Intern. At. Energy Agency Bull., 5: 24-6(Jan. 1963).

A review is given on practical applications of short-lived radioisotopes as compared to long-lived ones. Discussion is given on the advantages of short-lived radioisotopes, production of isotopes from small research reactors along with other methods, industrial uses, activation analysis, and applications in medicine, agriculture, and other fields. (P.C.H.)

**10254** LUCAS HEIGHTS RESEARCH ESTABLISHMENT. J. P. Baxter. Nucl. Energy, 22-3(Jan. 1963).

This description of the Lucas Heights Research Establishment conveyed some idea of the scale and physical scope of the work undertaken. The aims of their programs were stated briefly. Work of immediate practical value was outlined. (C.E.S.)

# BIOLOGY AND MEDICINE

## General and Miscellaneous

*Refer also to abstracts 11028 and 12026.*

**10255** (TID-17648) ACTION OF TRITIATED TETANUS TOXIN AND TOXOID UPON THE ANTIBODY FORMING MECHANISM. Period Covered: April 1, 1962 to March 31, 1963. Robert Speirs (New York. State Univ., Albany. Research Foundation). Dec. 1962. Contract AT(30-1)-3024. 9p.

Progress is reported in studies of hypersensitivity and antibody formation in mice in which tritiated antigens were used as tracers. Data are included from a study on the initiation of antibody production in irradiated mice and studies on hemopoiesis and antibody production as demonstrated in radioautograms of spleen, peritoneal fluid, bone marrow, and thymus from mice injected with antigen followed by tritiated thymidine and autopsied at specific times. (C.H.)

**10256** (TID-17699) GENETICAL EFFECTS OF RADIATION: A COMPARATIVE STUDY BETWEEN NATURAL LETHALS AND LETHALS INDUCED BY RADIATION IN POPULATION OF DROSOPHILA WILLISTONI. Progress Report. (São Paulo, Brazil. Universidade. Faculdade de Filosofia, Ciencias e Letras). Jan. 12, 1963. Contract AT(30-1)-2733. 15p.

Results are reported from a comparison of genetic variability in wild and laboratory populations of Drosophila. Data are included from studies on the frequency of mutants in an island population of D. willistoni after the introduction of natural and radioinduced mutants. Radioinduced and natural lethals were eliminated at the same rate. An analysis of results led to the conclusion that recessive lethals are far from being completely recessive and vary with environmental conditions. (C.H.)

**10257** (UCRL-10549) THE ENERGY CONVERSION APPARATUS IN PHOTOSYNTHESIS. Kenneth Sauer (California. Univ., Berkeley. Lawrence Radiation Lab.). Dec. 1962. Contract W-7405-eng-48. 28p.

An analysis of outstanding problems still presenting difficulty with respect to understanding the quantum-conversion process in photosynthesis is presented. Considerations of how some of these difficulties may be overcome are included. The dynamic process of energy conversion is considered in terms of photon absorption, electronic energy transfer, trapping in long-lived excited states, primary oxidants and reductants, and the electron transport chain leading to products representing stored chemical potential. The physical structure of the apparatus accomplishing this energy conversion is sought in the framework of the concept of the photosynthetic unit. The nature of this unit – its size, composition, arrangement and orientation of components, internal electrical and polarizability properties, and assembly and aggregation in the chloroplast – and the problems related to its determination are essential considerations in the overall approach to the understanding of the mechanism of energy conversion. (auth)

**10258** TRANSMISSION OF A FILTERABLE AGENT FROM RAT LEUKEMIA INDUCED BY X-RAY IRRADIATION AND TREATMENT WITH METHYLCHOLANTHRENE. F. Svec and E. Hlavay (Oncological Research Inst., Bratislava). Acta Haematol., 26: 252-60(1961)

Leukemia was induced in rats by combination of x irradiation and oral application of methylcholanthrene. The rats were irradiated by a single dose of 800 r, and methylcholanthrene was applied 3 times a week by stomach tube in a dose of 1 mg for 9 months. From 60 rats, myelogenous leukemia developed in 2 and lymphatic leukemia in 1. The myeloblastic leukemia proved to be transplantable and was maintained as MR-leukemia. After intravenous injection of 1 to $10 \times 10^6$ leukemic cells, obtained from the liver and spleen, the disease developed in adult rats in 6 to 10 days. As early as the 2nd or 3rd day after inoculation, leukemic infiltration of organs, especially liver and spleen, were seen. The rats died exhibiting signs of generalized leukemia within 10 days. If cell-free filtrates from the liver and spleen of rats bearing MR leukemia were injected into newborn and 4-week-old rats, myelogenous leukemia developed in the newborn group in 24% after a latency period of 520 days and in 33% of the 4-week-old group after 570 days, on an average. The induced leukemias were transplantable into both suckling and adult rats. Many of the injected animals, which did not develop leukemia, died of cirrhosis of the liver. The results suggest that the leukemia induced by irradiation and chemical carcinogen might be caused by a submicroscopic virus-like agent. (H.H.D.)

**10259** RADIATION DOSE AND RADIATION REACTION IN THE VAGINAL SMEAR IN CARCINOMA OF THE UTERINE CERVIX. Olle Kjellgren (Univ. of Gothenburg, Sweden). Acta Radiol., 58: 435-44(Dec. 1962). (In English)

No significant correlation could be proved between the radiation dose in the bladder and the radiation reaction in the vaginal smear, although the reaction varied with the dose in the rectum, and with rising age and decreasing hormonal activity in the smear. This does not prove, however, that the radiation reaction in the vaginal smear is dependent on the radiation dose. (P.C.H.)

**10260** DISTRIBUTION OF PLUTONIUM IN MICE. An Autoradiographic Study. Sven Ullberg, Arne Nelson, Harry Kristoffersson, and Arne Engstroem (Royal Veterinary Coll., Stockholm; Research Inst. of National Defence, Sundbyberg, Sweden; and Karolinska Institutet, Stockholm). Acta Radiol., 58: 459-71(Dec. 1962). (In English)

The distribution of $Pu^{239}$ was investigated by whole-body autoradiography in male mice, and pregnant and non-pregnant female mice, at 5 min up to 128 days after administration. The Pu was accumulated predominantly in the hard tissues but an uptake and retention were also observed in certain soft tissues such as the liver, ovarian follicles, fetal membranes, and mammary glands. (P.C.H.)

**10261** THE EFFECTS OF CHEMOTHERAPY AND IRRADIATION ON OVARIAN AND CERVICAL CANCER CELLS IN TISSUE CULTURE. J. G. Moore and W. W. Brandkamp (Univ. of Los Angeles). Am. J. Obstet. Gynecol., 82: 1019-30(Nov. 1961).

The effects of thio-TEPA (triethylenethiophosphoramide) and $Co^{60}$ radiation on various types of cultured cells were investigated. Ovarian cancer cells developed tolerance to thio-TEPA when it was added in sublethal doses, but did not develop tolerance to sublethal radiation exposure. The $ID_{50}$ (inhibitory dose) of radiation for the cells was ~200 r, and a linear relation was found between log cloning capacity and radiation dose between 100 and 500 r. Cloning capacity declined from 8.3% after 100 r to 11.1% at 500 r. Utilizing $ID_{50}$ doses of $Co^{60}$ and thio-TEPA, no significant difference

could be determined between the depressive effect of the injurious agents on cell population and their effect on cloning capacity of ovarian cancer cells (3-59) and cervical cancer cells (HeLa) in tissue culture. Whereas the primary effect noted following exposure to the alkylating agent was cytoplasmic shrinking and nuclear swelling, irradiation largely effected the nucleus with an increase in the numbers of multinuclear cells and aberrant nuclear forms. When the cells were subjected to both agents, nuclear aberrations became extreme and the development of long spinous cytoplasmic extensions from cell to cell was prominent. (H.H.D.)

**10262** A STUDY OF THYROID CANCER IN CHILDREN. Theodore Winship and Randi V. Rosvoll (Washington Hospital Center, Washington, D. C.). Am. J. Surg., 102: 747-52(Dec. 1961).

Children (286) with thyroid cancer were studied. Of these, 80% had received therapeutic radiation to the head or neck at some time during infancy or childhood. Most of the patients were treated for so-called enlarged thymus gland; others for hypertrophied tonsils and adenoids, hemangiomas, nevi, acne, eczema, and other benign diseases. The dosage administered varied from 180 to 6000, with an average of 600 r, but accurate data of radiation dosage were obtained for only 200 cases. The average interval between irradiation and discovery of carcinoma was 8.6 years. A history of previous irradiation in 80% of the children in the series provided convincing evidence that the use of therapeutic radiation to the neck region of children is a factor in the development of thyroid cancer in some cases. Irradiation of the thyroid region during infancy and childhood is a significant factor in thyroid carcinoma in children. (P.C.H.)

**10263** THE ACTION OF CENTRAL NERVOUS SYSTEM STIMULANTS IN THE IRRADIATED ANIMAL. R. Koch (Universität, Freiburg i. B.). Arch. Exptl. Pathol. Pharmakol., 241: 187-9(1961).

Attempts were made to determine the action of ionizing radiation on the central nervous system by its altered response to various drugs after irradiation. The influence of the drugs was tested by injecting them in mice 30 min before and 30 min or 6 days after whole-body irradiation with 400 r. Irradiation did not alter the $LD_{50}$ of any of the drugs: adrenaline, ephedrine, amphetamine, Pervitin (d-deoxyephedrine), and eventin. Slightly greater toxicity symptoms were noted with amphetamine after irradiation. The convulsive death of rats irradiated with high doses (up to 15000 r) was not altered by injection of the central stimulant Metrazole (35 mg/kg). A serous meningoencephalitis was noted in rats irradiated with 15000 r. $\beta,\beta'$-Iminodipropionitrile, a drug which intensely stimulates the cerebrum and induces a circling activity in mice, was tested for possible radioresistance properties. It significantly increased the $LD_{50}$ in female mice to 753 r from a control value of 634 r. Irradiation did not potentiate the action of the drug, and its suppressive effect on radioinduced death was no longer evident 6 months after the drug had been given. The results suggest that the action of central stimulants, unlike narcotics, is not greatly affected by irradiation of the central nervous system. (H.H.D.)

**10264** ACTION OF HIGH DOSES OF PARATHYROID HORMONE ON THE LEVELS OF STRONTIUM AND CALCIUM IN BONE AND BLOOD SERUM; A CONTRIBUTION TO THE MECHANISM OF ACTION OF PARATHYROID HORMONE. A. Schmidt and K. Zipf (Universität Munich). Arch. Exptl. Pathol. Pharmakol., 241: 209(1961).

In rats containing skeletal deposits of Sr, treatment with 0.3 units parathyroid hormone per g body wt produced only a slight rise in serum Sr levels, compared with the rise in Ca levels. Hence, the hormone may not accelerate the removal of Sr from bone when it is given in physiologic doses. However, when it is given in doses of 1 to 2 units/g, it does cause a withdrawal of Sr from spongy and compact bones of rats. At these doses, serum Sr levels rise but serum Ca falls. The results were interpreted on the basis of the postulated mechanism of action of parathyroid hormone. By causing the accumulation of citric acid, which forms a soluble complex with $Sr^{++}$ that is only slightly reabsorbed by the renal tubules, the elimination of Sr from the body is accelerated. (H.H.D.)

**10265** RENAL TUBULAR FINE STRUCTURE; STUDIED DURING REACTION TO ACUTE URANIUM INJURY. Robert S. Stone, Sergio A. Bencosme, Harrison Latta, and Sidney C. Madden (Univ. of California, Los Angeles). Arch. Pathol., 71: 160-74(Feb. 1961).

Acute U injury was studied in rats injected subcutaneously with 14.4 mg/kg $UO_2(NO_3)_2$, as the hexahydrate salt. For the following 6 days urinary volume and protein content were measured, and renal tubules were examined by light and electron microscopy. Enlargement of subbasilar compartments, apical swelling, and apical vacuolation were conspicuous and maximal in the first 2 days after injury, at the time polyuria was developing. The changes appeared to be related to disturbed fluid transport across cells. Enlargement of subbasilar compartments occurred in proximal, distal, and collecting tubules, implying that all 3 segments were concerned in fluid transport. Cytoplasmic vacuoles and bodies, including myelin figures and hyaline droplets, increased in number, size, and variety as proteinuria developed and necrotic debris appeared in tubular lumens. Necrosis, most extensive in proximal convoluted tubules, was not identified prior to pyknosis by any of several earlier changes in the fine structure. Earlier changes included loss of microvilli of brush borders, swelling of mitochondria and endoplasmic reticulum and Golgi systems, focal to general cytoplasmic edema, and margination of nucleoplasm. (H.H.D.)

**10266** COMMERCIAL PACKAGE IRRADIATION PLANT. Atom, No. 75, 19-20(Jan. 1963).

The first $Co^{60}$ irradiation plant designed specifically for medical purposes was put into continuous operation Nov. 10, 1962. The plant is used to sterilize plastic disposable hypodermic syringes. Discussion is given on the advantages of radiosterilization of medical supplies as well as other materials. (P.C.H.)

**10267** EXPERIMENTAL CORONARY ARTERIOGRAPHY BY SINGLE X-RAY EXPOSURE. Conway Don, George A. Bousvaros, John A. Hopps, and O. Z. Roy (Univ. of Ottawa). Brit. Heart J., 24: 269-73(May 1962).

A method for obtaining coronary arteriograms with a single x-ray exposure of $\frac{1}{30}$ sec or less is described. The quality and detail obtained with the single film is satisfactory and the method avoids the greater x-ray exposure encountered in cineradiography. The method was tested in dogs by injection of ~0.3 ml/kg of body wt of 50% Na diatrizoate through a radiopaque polythene catheter introduced percutaneously from the femoral artery. The tip was placed into the left aortic sinus and the single side-hole was thereby directed towards the right. A single x-ray film was triggered in diastole from the R wave of the electrocardiogram by a special electronic variable delay circuit. It was concluded that the technique should be simple to perform and of low risk in man. (H.H.D.)

**10268** CLINICAL RESULTS WITH CORTISONE ACTION IN THE GENERALIZED RADIATION SYNDROME, WITH SPECIAL CONSIDERATION OF DELTA-1-DEHYDROHYDROCORTISONE. B. Freyer (Röntgen- und Strahleninstitut, Staditisches Rudolph Virchow Krankenhaus, Berlin). Chemotherapia, 3: 189-99(1961). (In German)

The effects of adrenal steroid therapy were studied in 43 patients undergoing x-ray, Ra, and $Au^{198}$ treatments for malignant tumors. The postirradiation symptoms included anorexia, nausea, vomiting, other gastrointestinal disorders, and headache. In one group of patients who received up to 6000-r x-ray or 40 to 300 mC $Au^{198}$ doses, subsequent treatment with prednisolone at 5 mg/day completely prevented the symptoms. It was also effective when given in doses of 10 to 20 mg/day before irradiation in another group of patients. Prednisolone tended to prevent the rise in circulating eosinophils due to irradiation, and although it tended to aggravate the lymphopenic reaction after irradiation, it did not appear to produce undesirable side-effects. Combined treatment of a third group of irradiated patients with 10 mg prednisolone + 40 units thyroxine daily appeared to prevent serum electrolyte (K and Na) and blood sugar changes resulting from irradiation. The steroid also had a euphoric effect and reduced the pain of irradiated patients. (H.H.D.)

**10269** TREATMENT OF RADIATION ESOPHAGITIS: REPORT OF 51 CASES. David M. Sklaroff and Nicholas Karayannis (Albert Einstein Medical Center, Philadelphia). Current Therap. Res., 4: 356-62(July 1962).

Fifty-one patients under radiation treatment for malignant disease of the throat, neck, chest, or abdomen, exhibited symptoms of radiation esophagitis. Roentgen treatment had been administered daily for 14 to 21 days before esophageal symptoms became acute. Pain and dysphagia were particularly severe in lung cancer patients receiving massive irradiation from both anterior and posterior portals. Dysphagia interfered to a serious degree with nutrition. All standard treatment for esophagitis was unsatisfactory. Two teaspoonfuls oxethazaine, an oral anesthetic suspended in alumina gel, was administered to each patient 20 min before meals and at bedtime. Definite relief was generally evident after the 3rd or 4th dose on the 1st day; 84% were relieved in some degree after 24 hr, and in 71% the results were good to excellent. Since swallowing was less painful, food intake was increased and nutrition was improved. (H.H.D.)

**10270** FURTHER OBSERVATIONS ON GRAFT-VERSUS-GRAFT IMMUNOLOGICAL TOLERANCE IN RADIATION CHIMAERAS. Constance M. Clarke, Alena Lengerova, and H. Sí Micklem (Medical Research Council, Radiobiological Research Unit, Harwell, Berks, Eng.). Folia Biol. (Prague), 8: 335-40(1962). (In English)

Bone marrow cells injected into lethally irradiated mice were immunologically active against a second, marked, target inoculum of foreign fetal liver cells, while fetal liver cells under similar circumstances were not. The target cell population was completely eliminated by the bone marrow cells within 5 to 6 weeks, and it is suggested that probably the elimination occurred within the first few days. The failure of fetal liver cells to react against the target inoculum may be attributed to specific immunological tolerance towards the target antigens. Observations, made on the interactions between two grafts, throw light on the situation in allogeneic radiation chimeras where the target is the body of the host. Support is provided for the view that the decreased incidence of secondary disease in mice treated with foreign fetal (as opposed to adult) hematopoietic tissue is due to avoidance of the graft-versus-host immune reaction. (P.C.H.)

**10271** MEASUREMENT OF $Fe^{59}$ AND $Cr^{51}$ ACTIVITIES AT THE BODY SURFACE OF PATIENTS AFTER SIMULTANEOUS ADMINISTRATION OF BOTH ISOTOPES. W. Kuhn, U. Puyn, and W. Pribilla (Medizinisches Universitäts-Poliklinik, Cologne). Folia Haematol. (Frankfurt), 6: 248-51(Oct. 1961). (In German)

A method described for measuring the gamma radiation emitted by $Cr^{51}$ and $Fe^{59}$ is based on the fact that a Pb shield of appropriate thickness completely absorbs the relatively low-energy $Cr^{51}$ radiation while only partially absorbing $Fe^{59}$ gamma radiation. The absorption of $Fe^{59}$ by a particular filter will remain constant so that a correction factor can be used to determine the total $Fe^{59}$ radiation. Tests with various filters showed that <1% of the $Cr^{51}$ radiation passes a 10-mm Pb filter but allows ~55% of the impulses from $Fe^{59}$ to register. The values were independent of the total and proportional activities of the isotopes. Scintillometer determinations were made over various body regions of human subjects for up to 30 days after injection of 3-8 $\mu$C $Fe^{59}$ and 60-100 $\mu$C $Cr^{51}$-labeled erythrocytes. The results provided information on hematopoietic function and abnormal accumulation of red cells in the spleen. (H.H.D.)

**10272** RESULTS OF YEAR-LONG RADIOPHOSPHORUS ADMINISTRATION IN POLYCYTHEMIA VERA. Gisela Stecher (Städtliche Krankenanstalt, Cologne). Folia Haematol. (Frankfurt), 6: 285-8(Oct. 1961). (In German)

The results of treating 140 cases of polycythemia vera with $P^{32}$ over the last 9 yr are described. Oral doses of 4 to 5 mc $P^{32}$ or intravenous doses of 3 to 8 mc were given. Two-thirds of the patients experienced remission of the disease after the 1st $P^{32}$ dose, the remissions lasting 6 months or longer. The remainder of the patients required a 2nd dose. The average duration of remission was 20 months with over half exceeding 1 yr. The mean dose to obtain remission was 4.4 mc/yr. The required dose was directly related to the degree of splenomegaly, leukocytosis, and duration of the disease. The higher the initial circulating erythrocyte count before $P^{32}$ treatment, the greater the drop after treatment. The average drop in erythrocyte count was 1.8, 2.4, and $2.6 \times 10^6$ after $P^{32}$ doses of 3-5, 5-7, and 7 mc, respectively. In cases with initial counts of $7.5 \times 10^6$/cu mm the respective decrements in the counts were 2.6, 2.8, and 3.2. In 12% of the cases, $P^{32}$ treatment also resulted in transitory anemia, leukopenia, or thrombopenia. Five patients died of leukemia but the influence of the $P^{32}$ dose, if any, on this complication could not be determined. Twenty other patients died from the complications of polycythemia, such as thrombosis and hemorrhage. The recommended single dose is 4-5 mc $P^{32}$, which should be repeated after 3 to 4 months if there is an inadequate response to the 1st dose. (H.H.D.)

**10273** THE CIRCULAR AND ELLIPTICAL DELINEATION OF THE BEAM IN X RAY DIAGNOSTICS. P. Soila, T. Helelae, and I. Nurmi (Univ. of Turku, Finland). Fortschr. Gebiete Roentgenstrahlen Nuklearmed., 97: 622-30 (Nov. 1962). (In German)

The geometrical relationship between a rectangular and a circular (elliptical) delineation of the beam is worked out. On the basis of these calculations, practical examples of x-ray anatomy are given and applications of both types of diaphragm are suggested. The technical solutions are discussed. (auth)

**10274** MEDICAL USES OF RADIOACTIVE CALCIUM. REVIEW OF AN IAEA PROGRAMME TO PROMOTE THE

APPLICATIONS OF CALCIUM-47. Intern. At. Energy Agency Bull., 5: 15-17(Jan. 1963).

Efforts to bring $Ca^{47}$ into routine medical use are reviewed. Surveys were made on the need for the isotope, cost of production, and medical possibilities. The importance attached to $Ca^{47}$ is due to the special properties of the isotope, which make it the most valuable tool for many calcium studies by the radioactive tracer method. (P.C.H.)

**10275** TURNOVER RATE OF ZINC IN THE BODY AS DETERMINED BY THE STUDY OF $Zn^{65}$ IN RATS. P. Czerniak, A. Naharin, and N. Alexander (Israel Atomic Energy Commission, Rehovoth). Intern. J. Appl. Radiation Isotopes, 13: 547-56(Oct. 1962). (In English)

The specific and total radioactivity of $Zn^{65}$ in rats was examined in 24 different organs as they chronologically changed, both at short intervals and up to 3 weeks after intracardial injection. It was found that chronological changes exist in the zinc turnover rate in different organs. The maximum was reached in certain organs shortly after injection, for instance in the adrenals and especially in the pancreas. The pathology of the pancreas was complicated; therefore, the possibility of using the $Zn^{65}$ or $Zn^{69}$ for diagnosis of pancreatic diseases, by in vivo exploration, would be of importance. (P.C.H.)

**10276** THE PRECIPITATION OF RADIOACTIVE STRONTIUM FROM URINE. R. S. Bruce (Medical Research Council, Harwell, Berks, Eng.). Intern. J. Appl. Radiation Isotopes, 13: 565-71(Oct. 1962). (In English)

Factors that influence the precipitation of Sr were investigated with particular reference to the precipitation of radioactive Sr from urine without the addition of stable Sr as carrier. Strontium, along with Ca, may be precipitated quantitatively as the phosphate by rendering urine strongly alkaline with sodium hydroxide. The precipitate however is gelatinous and difficult to filter. When Sr is coprecipitated with Ca as the oxalate, which is more readily filtered, the precipitation of Sr is highly dependent on the concentration of Ca and the temperature at which the process is carried out. Provided that the concentration of Ca is not less than 2.5 m moles, good recoveries of radioactive Sr may be achieved by precipitating in the cold. Below this concentration the presence of 20% of alcohol produces a further significant reduction in the solubility of the Sr. There is no evidence that $Sr^{85}$ that has been metabolized and excreted in urine behaves differently from $Sr^{85}$ added to urine or in simple aqueous solutions. (auth)

**10277** FURTHER STUDIES ON THE THERMALLY INDUCED AGING OF DROSOPHILA MELANOGASTER. Bernard L. Strehler (National Heart Inst., Bethesda, Md.). J. Gerontol., 17: 347-52(Oct. 1962).

It was found that exposing Drosophila to ionizing radiation actually extends life expectancy, rather than shortens it. A comparison was made of the survivorship of flies reared and housed under sterile conditions with those living in cultures containing the yeasts which normally accompany Drosophila and which are one of their immediate food sources. The effect of irradiation on the mortality rate, such as to produce an extension of life, was largely lost or absent when the flies were reared under absolutely aseptic conditions. It was also shown that the regular replenishment of the housing and food of individually housed Drosophila produces a considerable extension of the life span. Thermal shock exposures at 38.5°C for periods ranging from ½ to 3 hr (in fractionated dosages) resulted in a significant increase in the age-specific mortality rate of the flies surviving beyond 7 days after the exposure. The results suggest that denaturative processes may mimic the effects of time on the aging of Drosophila as reflected in mortality rates. (H.H.D.)

**10278** AN APPRAISAL OF As-74 FOR LOCALIZATION OF BRAIN TUMOURS. W. Paul (Univ. of Toronto) and E. H. Botterell. J. Nucl. Med., 4: 1-8(Jan. 1963).

Arsenic-74 may be used to provide useful information in the diagnosis of intracranial space occupying lesions. The high degree of specificity for meningiomas may be put to good use in ruling out the likelihood of this particular type of neoplasm in certain patients. The overall successful localization of intracranial tumours and abscesses is discussed. Meningiomas are rarely missed, but the lower proportion of successful findings in certain gliomas may be explained by the smaller average dose given to the patient, and insistence on a readily discernable contrast on the records for a positive reading. (auth)

**10279** THE USE OF STRONTIUM-85 IN THE EVALUATION OF BONE METASTASES. A PRELIMINARY REPORT. Sydney Kofman, Howard H. Sky-Peck, Yvian Thibaudeau, Robert D. Ray, and Samuel G. Taylor (Univ. of Illinois, Urbana and Presbyterian-St. Luke's Hospital, Chicago). J. Nucl. Med., 4: 9-17(Jan. 1963).

A simple and practical method for scanning patients with vertebral metastases is described. A vertebral scan from C7 to L5 can be done in 30 to 60 minutes. This method is of value in studying patients with diffuse as well as isolated vertebral metastases. Patients with mixed or osteoblastic metastases have a higher uptake of strontium-85 than normals. Patients with osteolytic metastases have normal or increased uptake of strontium-85. Changes in uptake of strontium-85 as a result of therapy may be demonstrated within one to 2 weeks. (auth)

**10280** THE $I^{125}$ RADIOPULMONOGRAM. Maurice J. Small, Wade N. Miller, George C. Leiner, Herbert D. Strauss, and Sol Abramowitz (Veterans Administration Hospital, East Orange, N. J.). J. Nucl. Med., 4: 78-81 (Jan. 1963).

A technique for the simultaneous estimation of the ventilation of individual portions of both lungs utilizes a radiation source placed 6 ft in front of the chest wall with the exit beam measured by a dual scintillation detection system with probes placed over corresponding areas of both lungs. Respiration alters the linear density of the lung tissue and thereby alters the intensity of the exit beam. Applications of $I^{125}$ as a radiation source were investigated. Iodine-125 decays by electron capture to produce a 27.4-kev x ray and a 35.4 kev $\gamma$ ray with no $\beta$ emission. These photons are in the desirable range for this study and a $I^{125}$ source is light weight and portable, with a constant energy output. Results are presented of comparable findings with an x ray source and with a $I^{125}$ source. (C.H.)

**10281** USE OF RADIOYTTRIUM TO STUDY FOOD MOVEMENT IN THE SMALL INTESTINE OF THE RAT. C. S. Marcus and F. W. Lengemann (Cornell Univ., Ithaca, N. Y.). J. Nutr., 76: 179-82(Feb. 1962).

A new method, using $Y^{91}$ to label solid and liquid food, made it possible to calculate the rate of passage of food through the small intestine of rats. In food samples at pH 3, about 85% of the $Y^{91}$ stayed combined with the ground food and, as the pH increased, about 96% of the $Y^{91}$ was combined with the food at pH 8. Kidneys of rats given $Y^{91}$ orally showed no counts significantly above background. Total recovery of $Y^{91}$ in the digestive tracts of the rats averaged 97.9 ± 0.8%. Thus $Y^{91}$ does not undergo absorption and by staying with the food is a valid indicator of food location. Rats were killed at predetermined time intervals after feeding, and the percentage of the $Y^{91}$ dose present in por-

tions of the digestive tract was plotted against time for each alimentary segment; each curve was then resolved into input and outgo components. The highest rates of passage occurred in the proximal small gut; the rates then diminished continuously until, in the distal small intestine, they had decreased by a factor of almost 20. This nonabsorbable radio-indicator technique permitted in vivo experiments with undisturbed alimentary tracts, preserving the natural physiological conditions. Both liquid and solid food may be used, thus paralleling a normal diet. The method seems reliable because the data agreed with calculated values, and it is simpler and more accurate than the technique in which the whole gut is moved under a collimated GM tube. (H.H.D.)

**10282** EVALUATION OF BORON COMPOUNDS FOR USE IN NEUTRON CAPTURE THERAPY OF BRAIN TUMORS. II. STUDIES IN MAN. W. H. Sweet, A. H. Soloway, and R. L. Wright (Massachusetts General Hospital, Boston). J. Pharmacol. Expti. Therap., 137: 263-6(Aug. 1962).

Three boron compounds (3-amino-4-carboxybenzeneboronic acid, m-boronosuccinanilic acid, and sodium perhydrodecaborate) considered for use in the treatment of glioma patients by neutron capture irradiation, were evaluated in terminal patients. The 3rd compound was the most promising from the standpoint of low toxicity and was isolated unchanged, from urine. Five patients were given injections of Na perhydrodecaborate in doses ranging from 20 to 50 mg B/kg. Electroencephalograms showed only a few slow waves on the ipsilateral side, with no concomitant clinical changes even at the maximum dose, and there were no alterations in gastrointestinal function. The compounds or their B-containing metabolites were rapidly excreted, 50% appearing in the urine within 24 hr. Among all of the B compounds tested there was a definite correlation among chemical stability, biological inertness, and low toxicity. The highly reactive compounds have increased toxicity; whereas the highly stable ones are biologically inert. (H.H.D.)

**10283** MODIFICATION OF RADIATION INJURY BY LEUKEMOID LEUKOCYTES. L. H. Smith and C. C. Congdon (Oak Ridge National Lab., Tenn.). Lab. Invest., 10: 617-26(May-June 1961).

To define the mechanism by which leukemoid leukocytes promote recovery from x-ray injury, a comparison between the effects of leukemoid leukocytes and isologous bone marrow was made. Male and female BALB/c mice were exposed to 750 r, and within 4 hr after irradiation were given an intravenous injection of either $10 \times 10^6$ nucleated isologous bone marrow cells or $100 \times 10^6$ isologous leukemoid leukocytes. These numbers of cells were found to give consistently good 30-day survival. With both cell types recovery rates of white blood cell elements, red blood cells, and platelets were nearly alike after irradiation. Recovery rates of spleen and thymus, and body weight recovery were also nearly equivalent for the 2 treatments. Histology of recovering hemopoietic tissues was also similar, with the exception of lymphatic tissue elements. Total life span was apparently the same in both groups. Homologous leukemoid leukocytes were usually detrimental to irradiated mice, presumably because immunologically competent cells were present. (H.H.D.)

**10284** A METHOD OF ELECTRON MICROSCOPIC AUTORADIOGRAPHY WITH TRITIUM-LABELED CELLS IN A MAGNETIC FIELD. Carl G. Harford and Alice Hamlin (Washington Univ., St. Louis). Lab. Invest., 10: 627-35(May-June 1961).

A method is described that permits electron microscopy of autoradiographs obtained with $H^3$-labeled biological materials. Tracks produced in film emulsion by emitted beta particles were directly observed as reacted Ag grains formed by reduction of AgBr. Thin sections of HeLa cells labeled with tritiated thymidine were mounted on grids, covered with nuclear track emulsion, incubated, developed, and examined in the electron microscope. Reacted grains of the emulsion were found to have a distinctive appearance in the electron microscope because of a filamentous shape, and the identity of such grains was established by suitable controls. Because of distinct nuclear membranes in the electron micrographs, the location of reacted grains could be determined easily, and, although most of the grains were intranuclear, some scatter persisted. When the grids were exposed to a magnetic field during incubation, scatter was also not completely eliminated but a marked increase in number of reacted grains was found in the nuclei of the cells. The procedure appears to have advantages over previously used autoradiographic methods for intracellular localization of $H^3$-labeled compounds. (H.H.D.)

**10285** THE EFFECT OF DEUTERIUM OXIDE ON ECTROMELIA VIRAL INFECTION. Samuel W. French, Ann M. Hughes, and Benjamin V. Seigel (Univ. of California Medical Center, San Francisco). Lab. Invest., 10: 865-71 (Sept.-Oct. 1961).

Studies were made of the effect of $D_2O$ treatment on survival and pathologic changes in 2 groups of mice infected with mousepox. One group was given 30% $D_2O$ in the drinking water, and the other received ordinary water. A slight prolongation of the cumulative percentage survival on the seventh day after inoculation and a slight delay in the onset of necrosis in the liver, spleen, and lymph nodes was noted in animals given $D_2O$. The delay may be ascribed to a prolonged viral latent period and/or a reduced virus multiplication rate. The delay in onset of spleen and lymph node necrosis in the $D_2O$ group may have led to a heightened immune response, which may in part account for the reduced liver cell necrosis observed. (H.H.D.)

**10286** P-32 ISOTOPE TREATMENT OF ERYTHREMIA. W. Krasnik, M. Gembriczky, and S. Magas (Medical Academy of Poznan, Poland). Orv. Hetilap, 103: 2184-7(Nov. 18, 1962).

With the use of radioactive $P^{32}$ a considerable percentage of patients with erythremia showed clinical and hematological remission. The subjective improvement preceded the hematological gains. With careful and individual evaluation of the dosage no side effects were observed. (OTS)

**10287** PRELIMINARY REPORT ON THE LOCALIZATION OF BRAIN LESIONS WITH $I^{131}$-LABELED POLYVINYLPYRROLIDONE. W. Newlon Tauxe, Richard E. Sedlack, Paul J. Pitlyk, and Frederick W. L. Kerr (Mayo Clinic, Rochester, Minn.). Proc. Staff Meetings Mayo Clinic, 37: 109-11(Feb. 14, 1962).

Because of its short physiologic half life (~1 day) and high molecular wt (40000), which approximates that of serum albumin, $I^{131}$-polyvinylpyrrolidone investigated for the detection of brain lesions by scintillometry. Lesions were produced in cats by intracerebral injection of nitrogen mustard and the cats were injected intravenously with the tracer 2 to 7 days later. Localization of the lesions, which proved to be only a few mm in diameter, was excellent. Some radioactivity accumulated in the nasal mucosa. The highest lesion/brain uptake ratio was noted 72 hr after injection of the tracer, but since its turnover time is shorter in man than in cats, a shorter time interval may be optimal in human studies. (H.H.D.)

**10288** THE USE OF RADIATING MICROSPHERES IN THE TREATMENT OF EXPERIMENTAL AND HUMAN MALIGNANCY. Young Song Kim, James W. LaFave, and Lloyd D. MacLean (Ancker Hospital, St. Paul). Surgery, 52: 220-31(July 1962).

A method is described for delivering a cancerocidal agent via blood vessels to a tumor zone by the use of ceramic microspheres of uniform size containing cationic radioisotopes with specific activities as high as $10^4$ C/g. Microspheres containing $Sc^{46}$, a strong $\gamma$ emitter, were used for tracer studies because of its convenient half life (85 days) and ease of detection. The spheres used were of uniform diameter (60 ± 5 $\mu$) and specific gravity, and their specific activity was 1 $\mu$C/mg. Microspheres containing $Y^{90}$ were used in the range of 0.1 to 1 mC/mg. Distribution of radioactive spheres in the lungs of dogs was uniform when injection was made into a peripheral vein. Spill-over of radioactivity into the general circulation was less than 5%, so for practical purposes this method represents a therapeutic agent which is taken up completely by the first capillary bed encountered. The normal dog liver tolerates doses of internal radiation from $Y^{90}$ microspheres up to and including 100 mC in a single dose with only transient dysfunction, $Y^{90}$ microspheres given to simulate adjuvant therapy had a beneficial effect on the growth of V2 carcinoma in the rabbit lung. $Y^{90}$ microspheres were used to treat 17 patients. Objective improvement was obtained in 6 patients. It is suggested that response to this therapy and chemotherapy is related to vascularity of the tumor. Massive doses of radiation (up to 100000 rad) can be given to a local area by this method without danger of bone marrow depression or general debility. (P.C.H.)

**10289** MUTUAL TOLERANCE OF DONOR AND HOST LYMPHO-RETICULAR CELLS IN LASTING TOLERANCE. Carlos Martinez, June M. Smith, and Robert A. Good (Univ. of Minnesota, Minneapolis). Transplant. Bull., 30: 123-6 (Oct. 1962).

Evidence is presented indicating that in mice with long lasting tolerance the lympho-reticular cells of donor origin, as well as those of host origin, develop a tolerant state. Homologous disease does not develop in sublethally irradiated (A × C3H) $F_1$ recipients upon injection of cells from donors made tolerant at birth by intravenous injection of spleen cells taken from A strain donors. Lymphoid cells from C3H strain mice rendered tolerant to A strain tissues protect against fatal irradiation and do not produce late deaths due to homologous disease. The protection afforded against lethal irradiation in the $F_1$ hybrid by cells from one parent strain tolerant to the cells of the other parent strain is comparable to the protection provided by cells from isologous $F_1$ hybrid donors. These observations provide additional evidence that adult cells, just as embryonic cells or cells from neonatal animals, can develop immunologic tolerance. (auth)

**10290** CORRELATION OF PLAQUING EFFICIENCY AT 40°C IN $D_2O$ WITH LIMITED THERMAL EXPOSURE RATIOS. Richard I. Carp (Wistar Inst. of Anatomy and Biology, Philadelphia). Virology, 18: 151-2(Sept. 1962).

Heavy water caused a 50-fold increase in the virus yield from cells infected with CHAT virus (an rct/40$^-$ strain) and incubated at 40°C. Also, the plaquing efficiency of CHAT virus at 40° compared to 37° was increased from about 1 in $10^5$ in standard medium to about 1 in 2 in medium containing $D_2O$. The plaques that developed at 40° in medium containing $D_2O$ were picked, passed in standard medium at 37°, and tested for their rct/40 character. A sensitive test of the rct character, the limited thermal exposure test (LTE) test, indicated that there was a difference in the rct character. Thus, the LTE ratios of the $D_2O$ plaque pools were consistently higher than those of the parental CHAT pool. Plaque pools derived from CHAT plaques that had developed at 37° in medium containing $D_2O$ had LTE ratios similar to those obtained for the parental CHAT pool. A correlation was found between a plaque pool's LTE ratio and its tendency to form plaques at 40° in the presence of $D_2O$. The results indicate that: CHAT populations are composed of particles that vary slightly with regard to their rct/40 character, and the correlation in the 2 sensitive measures of rct character (the LTE ratio and plaque-forming potential at 40° in $D_2O$) explains the previously noted fact that 40° $D_2O$-plaque pools had a higher LTE ratio than the parental CHAT pool. (P.C.H.)

**10291** DEOXYRIBONUCLEIC ACID-SYNTHESIZING PERIPHERAL BLOOD CELLS STUDIED BY IN VITRO UPTAKE OF $^3$H-THYMIDINE. 3. STUDIES ON DEOXYRIBONUCLEIC ACID-SYNTHESIZING CELLS IN PERIPHERAL BLOOD OF RABBITS EXPERIMENTALLY TREATED WITH X IRRADIATION, INJECTION OF COLLOIDAL SILVER SOLUTION, AND ACUTE BLEEDING. Yoshiaki Misawa (Yokohama Univ., Japan). Yokohama Med. Bull., 12: 31-41(Feb. 1961).

The ability of peripheral blood cells to incorporate $H^3$-thymidine into DNA was tested in vitro after whole-body x irradiation of rabbits with 500 r. A marked increase in the percentage of labeled cells was noted in the irradiated group and this became maximal on the 3rd to 5th day after irradiation. Acute hemorrhage produced a similar rise in the labeling of peripheral blood cells but the maximum occurred later than after irradiation, or on about the 7th post-hemorrhage day. Blockade of the reticuloendothelial system (RES) of rabbits by intravenous injection of colloidal Ag also caused a rise in labeling of blood cells. The rise was less marked than after irradiation or hemorrhage and became maximal on the 3rd to 5th day. The bone marrow and RES of young rabbits were more sensitive to the 3 agents than those of adult rabbits. (H.H.D.)

## Biochemistry, Nutrition, and Toxicology

**10292** (BNL-6106) PROBLEMS OF BONE MARROW CELL TRANSFUSIONS. T. M. Fliedner, R. Stodtmeister, L. Meyer, and E. P. Cronkite (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT-30-2-GEN-16]. 24p.

**It was demonstrated in animals that bone marrow cell transfusions are effective in repopulating the marrow of irradiated recipients under certain conditions. They are most effective if isologous or autologous cells are used. Heterologous and homologous bone marrow cell transfusions may be effective in repopulating the damaged marrow of the recipient, but immunological complications are responsible for a so-called secondary disease, caused by a graft-versus-host or host-versus-graft reaction, which may be fatal. Homologous marrow cell transfusions have been employed in patients after massive radiation therapy and after a radiation accident. However, the results have not been satisfactory. There is no satisfactory evidence for a permanent homograft of bone marrow in man. Autologous marrow transfusions have been used clinically to treat the marrow failure resulting from massive chemotherapy or radiotherapy of generalized malignant diseases. This approach appears to provide the best possibilities of studying the principles of the effects and mechanisms of**

action of bone marrow cell transfusions at the clinical level. Tritium–labeled thymidine has been used experimentally to label bone marrow cells before their transfusion into irradiated recipients. It has been possible to follow their fate and dilution of the label by mitosis. This method appears to be useful in clinical studies, particularly with autologous transfusions, where other cell identification methods are not applicable. (45 references.) (auth)

**10293** (BNL-6108) COMPARATIVE KINETICS OF $Ca^{47}$ AND $Sr^{85}$ IN MAN. S. H. Cohn, S. W. Lippincott, E. A. Gusmano, and J. S. Robertson (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT(30-2)-Gen-16]. 28p.

The kinetics of skeletal metabolism of $Sr^{85}$ and $Ca^{47}$ over a 30-day period were characterized in terms of accretion, exchange, and biological loss (resorption and long-term exchange). A four-compartment model of the kinetic metabolic system for both elements was developed on an analogue computer. Computer analysis yielded estimates of compartment sizes and flow rates between compartments. Initially the skeletal accretion rate and exchange capacity are very similar for Sr and Ca. Differences in the retention appear after 10 days, when the metabolic response is characterized chiefly by binding in the crystal lattice and long-term exchange. The data suggest that identical roles in skeletal metabolism for Ca and Sr tracers over long periods of time cannot be postulated on the basis of the metabolic similarities observed in the short interval following administration. (auth)

**10294** (COO-226) RESEARCH IN RADIOBIOLOGY. Semi-Annual Report of Work in Progress on the Chronic Toxicity Program. Thomas F. Dougherty (Utah. Univ., Salt Lake City. Coll. of Medicine). Sept. 30, 1962. Contract AT(11-1)-119. 135p.

Separate abstracts were prepared on 10 sections of this report covering investigations on the chronic toxicity of isotopes of radium, plutonium, thorium, and strontium in dogs. (C.H.)

**10295** (COO-226(p.3-33)) INJECTION TABLES. (Utah. Univ., Salt Lake City. Coll. of Medicine).

Data are tabulated on the injection dose of $Ra^{226}$, $Pu^{239}$, $Ra^{228}$, $Th^{228}$, and $Sr^{90}$ administered intravenously to dogs in studies on the toxicity of various dose levels of these radioisotopes. (C.H.)

**10296** (COO-226(p.35-49)) GINGIVAL ULCERATION IN BEAGLES INDUCED BY Ra-226, Ra-228, OR Th-228. G. N. Taylor, W. R. Christensen, W. S. S. Jee, and C. E. Rehfeld (Utah. Univ., Salt Lake City. Coll. of Medicine).

Relatively high retained burdens of $Ra^{226}$ given by multiple injections and $Ra^{228}$ or $Th^{228}$ administered via single injections to beagles induced a severe type of gingival ulceration in part of the animals studied. This oral condition was characterized by marked sloughing of the gums; thus exposing the mandible and/or maxilla. It was invariably preceded by underlying bony changes and appeared to be secondary to this and related vascular impairment. The tendency toward healing was minimal. (auth)

**10297** (COO-226(p.50-6)) THE EFFECTS OF MULTIPLE $Ra^{226}$ (RADIUM) INJECTIONS ON THE PERIPHERAL BLOOD VALUES OF THE BEAGLE. Jean H. Dougherty (Utah. Univ., Salt Lake City. Coll. of Medicine).

The hematological changes observed in beagles receiving a total of 10 $\mu$c/kg of $Ra^{226}$ in six intravenous injections over a ten-month period are reported for the lifespan of the dogs. A sustained leukopenia, lymphopenia, and eosinopenia are found and an anemia is noted terminally. These findings are compared to those seen in beagles receiving the same amount of $Ra^{226}$ in a single intravenous injection. (auth)

**10298** (COO-226(p.58-65)) SOLVENT EXTRACTION OF PLUTONIUM WITH PRIMARY AMINES. SOME APPLICATIONS TO PLUTONIUM EXTRACTION FROM BIOLOGICAL MATERIAL, ESPECIALLY URINE. F. W. Bruenger, B. J. Stover, and D. R. Atherton (Utah. Univ., Salt Lake City. Coll. of Medicine).

An accurate and simple procedure for the determination of plutonium in biological materials was developed. Concentrated urine, or a solution of bone ash, is made at least 1M in $H_2SO_4$, and plutonium is extracted with a mixture of $C_{18}$ to $C_{23}$ highly branched primary amines in xylene. Plutonium is then extracted from the organic phase with 8M HCl and measured by alpha counting. (auth)

**10299** (COO-226(p.66-70)) MEASUREMENT OF $Sr^{90}$; INTERLABORATORY AND INTERSTANDARD COMPARISONS. David R. Atherton, Betsy J. Stover, C. W. Mays, and R. J. Della Rosa (Utah. Univ., Salt Lake City. Coll. of Medicine).

Measurements made on the same solutions of $Sr^{90}$ by the AEC Project No. 6 laboratory at Davis, California and this laboratory yield values which, for all practical purposes, are identical. Comparison of standard solutions of $Sr^{90}$ supplied by the U. S. National Bureau of Standards and the Radiochemical Centre of the United Kingdom shows their certified values to be in excellent agreement. (auth)

**10300** (COO-226(p.71-77)) RADIUM STUDIES IN A MAN SOON AFTER INJECTION. C. W. Mays, W. R. Christensen, et al. (Utah. Univ., Salt Lake City. Coll. of Medicine).

Radium was injected in the first of several subjects in a projected study of the early retention of radium in man. Results of total–body counting during the first two months are presented. Radium was also measured in the feces, urine, and plasma. (auth)

**10301** (COO-226(p.78-85)) DETERMINATION OF LOCALIZED ALPHA DOSE FROM SURFACE AND VOLUME DEPOSITS OF $Pu^{239}$, $Th^{228}$, AND $Ra^{226}$. Charles W. Mays and Kendrick A. Sears (Utah. Univ., Salt Lake City. Coll. of Medicine).

Formulas are given for expressing the average $\alpha$ dose-rate to the 10 micron layer of soft tissue adjacent to a flat uniformly contaminated surface or volume. These formulas are applied to the localized dosimetry of $Pu^{239}$, $Th^{228}$, and $Ra^{226}$. (auth)

**10302** (COO-226(p.86-94)) RADIUM DOSIMETRY. Kendrick A. Sears, Webster S. S. Jee, and Charles W. Mays (Utah. Univ., Salt Lake City. Coll. of Medicine).

A project has been set up to determine the specific activity in microscopic areas of four bones from radium-injected beagles. This is an attempt to establish a relationship between local concentrations of activity and histopathology and to try to assess the relative importance of hotspots and diffusely labeled bone in producing pathology. The data collected so far are presented and a formula is given to determine the average terminal dose rate in rads/day over the 10 microns of soft tissue adjacent to the bone. (auth)

**10303** (COO-226(p.95-127)) THE LONG-TERM EFFECTS OF PLUTONIUM-239 IN ADULT BEAGLES. W. S. S. Jee, B. J. Stover, et al. (Utah. Univ., Salt Lake City. Coll. of Medicine).

Data are summarized from nine years of work on the toxicity of plutonium-239 in the skeleton of adult beagles. Intravenous injections of 2.8, 0.90, 0.30, and 0.096 μc/kg plutonium (+4) citrate induced $^{7}/_{9}$, $^{12}/_{12}$, $^{12}/_{12}$, and $^{7}/_{8}$ bone cancers. The average accumulated rads to the skeleton varied from 326 ± 70 to 6470 ± 1590 rads. Systematic radiographic and histologic search for bone tumors revealed multiple primary osteosarcomas and the anatomical distribution for each dose level. The anatomical distribution of osteosarcomas differed for each dose level. A squamous cell carcinoma invading the frontal bone was detected in the 0.096 μc/kg group. The skeleton exhibited radiographically and histologically extensive gross tissue damage in the higher dose levels, while isolated empty lacunae and a slight amount of resorption occurred in the trabeculae of 0.096 μc/kg dogs. In contrast to the minimal damage of the spongiosa of the 0.096 μc/kg group, the tibial compacta of the same skeleton exhibited a high incidence of canal plugs and loss of osteocytes in osteons. The distribution and redistribution of plutonium were reviewed to emphasize the non-uniformity of the radionuclide in osseous tissue. Detailed radiochemical analyses of bone samples of four beagles injected with 2.8 μc/kg $Pu^{239}$ also revealed a wide variation in the concentration of plutonium in the same bone of several dogs and in various bones of a given dog. The amount of activity in the mandible and shaft of the humerus was fairly low. Correspondingly, the tumors from the shafts of long bones and the mandible were restricted to the higher dose levels. Highest concentration of the vertebral column was in the sacrum and thoracic vertebrae, but most of the tumors arose in the cervical and lumbar regions. The concentrations of plutonium in ribs, scapulae, and pelves were in the same range as the vertebrae, but more pelvic tumors were detected. The addition of lower dose levels, when the animals and space are available to insure a safety factor in the experiment, was announced. (auth)

**10304** (COO-226(p.128-30)) FURTHER STUDIES ON THE EFFECTS OF ESTRADIOL VALERATE AND SULPHATED MUCOPOLYSACCHARIDES ON HYPEROSSIFICATION IN AUTOGENOUS TIBIAL TRANSPLANTS. H. K. Suzuki and W. S. S. Jee (Utah. Univ., Salt Lake City. Coll. of Medicine).

Preliminary results are reported from an investigation of techniques for use in studies of vascularity of spongy bone. Results are reported from an evaluation of the India ink-gel injection method and the micropaque-gel method for the demonstration of vascularization in bones. Data are included from a study on the effects of estradiol valerate and sulfated mucopolysaccharides on hyperossification in mice autogenous tibial transplants. (C.H.)

**10305** (HASL-120) THE SIGNIFICANCE OF URINE URANIUM EXCRETION DATA. M. Lippmann, L. D. Y. Ong, and W. B. Harris (New York Operations Office. Health and Safety Lab., AEC). Feb. 1962. 46p.

Urine uranium excretion data for persons exposed to uranium by inhalation are analyzed. Data from both chronic and single massive exposures are included, and a generalized excretion pattern, applicable to any uranium compound absorbed by inhalation, is proposed. For a single exposure, the subsequent urine excretion rate, y, can be described as a function of time, t, by the equation in the form: $y = \alpha t^{-\beta}$, with $\beta = 1.5 \pm 0.2$. For multiple or chronic exposures, excretion following the final exposure can be described by three equations of the same form. The first and third equations have $\beta = 1.5 \pm 0.2$, while the second equation covers the intermediate phase with $\beta = 0.3 \pm 0.1$. The time range covered by the intermediate phase is a function of the level and duration of the exposures. Using this model, estimates can be made of previous exposure levels, future excretion values, and body burdens, based on appropriate urine data. It is shown that it is not usually practical to use urine samples to monitor individual exposures. Such an evaluation is possible only with a suitable series of samples collected at known intervals past the exposure. It is also shown that it is not possible to determine chronic exposure levels from routine urine samples. Chronic exposure levels and body burdens can only be estimated with a sample series collected two or more weeks after the termination of exposure. This report also contains three Appendices describing the detailed mathematical manipulations made on the available urine data and on some trends suggested by the data as plotted in various forms. (auth)

**10306** (HW-SA-2577) FACTORS AND CONDITIONS MODIFYING THE ABSORPTION AND RETENTION OF CHRONICALLY INGESTED RADIOSTRONTIUM. Roy C. Thompson (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). [May 9, 1962]. Contract AT(45-1)-1350. 25p.

The information available on chronically ingested $Sr^{90}$ is reviewed: fallout, studies of natural Sr content in human beings, and chronic feeding experiments on animals. Plots are given for $Sr^{90}$ content in human bone of varying age, $Sr^{90}$ content in rat bone for various Ca diets, and relationships of $Sr^{90}$, $Ca^{45}$, and total Ca in bone and diet in rats. (D.L.C.)

**10307** (TID-17522) IN VITRO BINDING STUDIES OF RARE EARTHS AND RARE EARTH CHELATES TO PROTEINS AND NUCLEIC ACIDS. Final Report, December 1, 1961 to November 30, 1962. Eugene Y. Berger (New York Univ., New York. Medical Center). Contract [AT(30-1)-3015]. 9p.

Equilibrium dialysis and pressure filtration were employed in in vitro tracer studies of the binding of rare earth and rare earth chelates to blood serum proteins and nucleic acids. Data are presented on the binding of $Y^{91}$ to human serum α globulin and calf thymus desoxyribonucleic acid (DNA) and the binding of $La^{140}$ and $La^{140}$ chelate to albumin, α globulin, and DNA. (C.H.)

**10308** (TID-17542) DISTRIBUTION AND EXCRETION OF RADIOACTIVE RARE EARTH COMPOUNDS IN MICE. Betty Rosoff, Elsie Siegel, Grady Williams, and Herta Spencer (Montefiore Hospital, New York and Veterans Administration Hospital, Hines, Ill.). [1962]. Contract AT(30-1)-1763. 17p.

The distribution and excretion of radioactive scandium, yttrium, lanthanum, and samarium, intravenously administered to mice in ionic and chelated form, are described. The strong rare earth chelates (ScEDTA and YEDTA) are well excreted and very little is retained in the tissues. The weak and intermediate chelates are largely deposited in liver and spleen, and the chelates with intermediate stability (YNTA, ScNTA and SmEDTA) show relatively high concentration in bone. A possible explanation for the difference in tissue distribution of the various rare earths on the basis of colloidal aggregates, chelate stability, and protein binding is suggested. (auth)

**10309** (TID-17644) LOCAL DISTRIBUTION AND RETENTION OF RADIUM IN MAN. R. E. Rowland (Argonne National Lab., Ill.). Oct. 1962. Contract [W-31-109-eng-38]. 18p. (UAC-6939)

The mechanisms of uptake and release of radium from

the skeleton are discussed. Data are presented from studies on the microscopic distribution of Ra in bone as it exists terminally. The results are based on microradiographs of bone sections, stripping film autoradiographs, and the quantitative analysis of $\alpha$ track plates. (C.H.)

**10310** (TID-17789) FISSION PRODUCT METABOLISM AND RESPONSE IN LABORATORY AND DOMESTIC ANIMALS; PLANNING STUDY FOR EVALUATION OF RADIOACTIVE CONTAMINATION OF THE FOOD CHAIN. Progress Report, April 1, 1962-January 31, 1963. C. L. Comar, R. H. Wasserman, F. W. Lengemann, D. N. Tapper, J. R. Georgi, E. L. Gasteiger, J. C. Thompson, Jr., R. Alexander, and W. Giese (New York. State Univ. Veterinary Coll., Ithaca and Cornell Univ., Ithaca, N. Y.). Contract AT(30-1)-2147. 75p.

Results are summarized from a series of studies on metabolic processes governing the movement of fission products in laboratory and domestic animals. Emphasis was placed on the monitoring of food supplies and the development and evaluation of survey methods for the evaluation of radioactive contamination of the food chain. The relative availability of $I^{131}$ from milk as compared to availability from inorganic sources was measured. Data are included from studies on the renal excretion of Ca and Sr, the effects of lactose and vitamin D on calcification in normal and rachitic chicks, the effects of dietary Na and K on $Cs^{137}$ retention in the rat, and the effects of ultraviolet light on single nerve fibers. (C.H.)

**10311** (Y-KB-1) EXCRETION OF URANIUM FROM MIXED EXPOSURES UNDER INDUSTRIAL CONDITIONS. L. M. Scott (Union Carbide Nuclear Co. Y-12 Plant, Oak Ridge, Tenn.). May 22, 1962. Contract W-7405-eng-26. 16p.

Uranium urinalysis data on 157 individuals, who continued to submit urine samples after they transferred out of uranium processing areas, were analyzed. These individuals had been exposed to material with varying degrees of solubility. The mathematical function describing the excretion of uranium and the time required for the body to eliminate 50% of the original body burden, as determined by urinalysis, were the factors of interest. The data were fitted with both an exponential function and a power function. The power function resulted in the best fit. The time required for a 50% reduction in body burden was ten days with a 95% confidence interval of five to twenty-one days. A second 50% reduction required an additional ninety-five days. Comparisons between these data and other reports of elevated levels of excretion are presented. (auth)

**10312** (AEC-tr-5600) COMPARISON OF THE INJECTION OF $S^{35}$-SULFIDE AND $S^{35}$-SULFATE IN THE BODY ALBUMIN OF RATS. Marianne Waldschmidt. Translated for Oak Ridge National Lab., Tenn. from Biochem. Z., 335: 400-7(1962). 14p.

Rat liver homogenates were incubated with a solution of $S^{35}$-sulfide and $S^{35}$-sulfate, respectively. The protein isolated from the homogenate incubated with sulfide had a 20- to 50-fold higher $S^{35}$-activity than that observed after the incubation with $S^{35}$-sulfate. If the above-mentioned $S^{35}$-active solutions were injected intracardially into rats, the body protein contains an $S^{35}$-activity which is up to 8 times higher after the injection of $S^{35}$-sulfide. The time course of the $S^{35}$-activity in proteins shows a maximum after 2 hrs with liver, kidney, spleen, and serum; with muscle, the maximum is reached after 11 hrs. After the injection of $S^{35}$-sulfate, the time course of the $S^{35}$-activity in the proteins is flatter; the initial values are generally lower. After about 4 days, the $S^{35}$-activity of the protein after $S^{35}$-sulfide administration is as high as it is after $S^{35}$-sulfate. Thirty minutes after the application, a considerable part of the $S^{35}$ can be found in the intestine. Thus, an influence of the intestinal bacteria has to be discussed, particularly because the in vivo assimilation of sulfate is found to be higher than in the in vitro experiments. If $S^{35}$-cysteine is isolated from the proteins after hydrolysis, the results in regard to $S^{35}$-activity are the same as those found with the pure protein. It appears therefore that inorganic sulfate cannot be used for the protein synthesis in higher organisms, as the latter are not able to reduce the sulfate to sulfide. (auth)

**10313** BERYLLIUM DISEASE: A CONTINUING DIAGNOSTIC PROBLEM. Harriet L. Hardy (Massachusetts Inst. of Tech., Cambridge). Am. J. Med. Sci., 242: 150-5 (Aug. 1961).

The clinical picture and symptoms of chronic beryllium intoxication are reviewed. A registry of cases of beryllium disease begun in 1951 now has on file 650 records, and 40 cases have been entered since January, 1959. The initial clinical picture is usually one of pulmonary involvement. The most frequent cause of death is cor pulmonale. Pulmonary insufficiency is next in frequency, and complicating infection is the third most important. There are only 3 cases of lung cancer in the 650 registry cases despite evidence that beryllium produces pulmonary cancer in laboratory animals. (P.C.H.)

**10314** THE ROLE OF CHLOROPLAST LIPOPROTEIN IN PROTEIN SYNTHESIS. N. M. Sisakyan, E. N. Bezinger, and A. S. Marchukaitis (Bakh Inst. of Biochemistry, Academy of Sciences, USSR). Doklady Akad. Nauk SSSR, 147: 1493-4(Dec. 21, 1962). (In Russian)

It was shown previously by tracer experiments that lipoproteins rapidly assimilate amino acids. To determine the stage of protein biosynthesis, chloroplasts were isolated from bean leaves, and incubated with $C^{14}$-tagged alanine in the presence of Mg in a sugar-potassium phosphate buffered solution (pH of 7) for periods of 30 and 60 minutes. Six tests, three without the addition of, and three with the addition of 1 $\mu$mols of ATP or 5 $\mu$mols of AMP, were run for each incubation period. It was found that unpurified ATP inhibited the assimilation of alanine by the lipoid part of the protein fraction by 50 to 60%. The assimilation of alanine by the protein part of the lipoprotein fraction was completely inhibited. The inhibition was due to an AMP impurity in the ATP. No inhibition was noted after purifying the impure ATP on a Dowex 1 column. It was found that AMP inhibited the assimilation of alanine by the lipoid half of the lipoprotein fraction by 40%, and completely inhibited the assimilation of alanine by the protein part of the lipoprotein fraction. These data indicate that the lipoproteins participate directly in the biosynthesis of protein in chloroplasts. (TTT)

**10315** EFFECT OF CENTIMETER BAND RADIO WAVES ON THE ABSORPTION OF AMINO ACIDS, CHLORIDES AND WATER IN THE STOMACH AND INTESTINE. V. R. Feitelberg-Blank (Inst. of Physiotherapy, Ukrainian SSR). Dopovidi Akad. Nauk Ukr. RSR, No. 10, 1367-70 (1962). (In Ukrainian)

The absorption of amino acids, chlorides, and water was studied in the normal state and under the effect of high frequency of the centimeter waveband on 6 dogs with Pavlov pouches (3) and isolated loop of the small intestine (3 dogs). The effect of a 50 watt radio-wave field acting on the organism for 10 minutes on the absorptive capacity of the stomach and intestine was studied. The investigations

showed that centimeter band radio waves intensify absorption of amino acids, chlorides, and water in the stomach and intestine. (auth)

**10316** PROCEEDINGS OF THE HANFORD SYMPOSIUM ON THE BIOLOGY OF THE TRANSURANIC ELEMENTS, RICHLAND, WASHINGTON, 28-30 MAY 1962. Roy C. Thompson, ed. Health Phys., 8: 561-784(Dec. 1962).

Separate abstracts have been prepared on 24 papers. Ten papers included in this volume were previously abstracted and appeared in NSA. (C.H.)

**10317** TOXICITY OF PLUTONIUM IN MICE. Miriam P. Finkel and Birute O. Biskis (Argonne National Lab., Ill.). Health Phys., 8: 565-79(Dec. 1962).

Plutonium citrate given intravenously to mice reduced life expectancy, decreased hemoglobin and leukocyte concentration in the peripheral blood, increased the incidence of liver degeneration, and induced osteogenic sarcomas. In none of these respects were the lowest dosage groups, 0.04 and 0.08 μc/kg, different from the control group. (auth)

**10318** THE COMBINED TOXIC EFFECTS OF PLUTONIUM PLUS X-RAY IN RATS. J. E. Ballou, L. A. George II, and R. C. Thompson (General Electric Co., Richland, Wash.). Health Phys., 8: 581-7(Dec. 1962).

Under conditions of acute administration, the lethal effect of either x rays or plutonium is markedly increased by their combined application. If x irradiation is delayed for 14 days after plutonium administration, the combined lethal effect is reduced. Under conditions of chronic x irradiation, survival time is substantially shortened by a plutonium burden of 5 μc/kg. Plutonium retention and distribution is not affected by concurrent x irradiation. The lethal effect of combined radiation is not influenced by the sequence of radiation application; however, it may be significantly altered by prompt DTPA treatment. (auth)

**10319** FURTHER STUDIES OF THE METABOLISM OF $Pu^{239}$ IN ADULT BEAGLES. Betsy J. Stover, D. R. Atherton, F. W. Bruenger, and D. S. Buster (Univ. of Utah, Salt Lake City). Health Phys., 8: 589-97(Dec. 1962).

Studies of excretion, plasma concentration, and soft tissue retention of $Pu^{239}$ in adult beagles have been extended through the period 4 to 8 years following a single intravenous injection. Rate of excretion was low and consistent with extrapolation of results of earlier studies; hence, the retention equation for the first 4 years can be used to 8 years. Terminal plasma concentrations were lower than predicted. Long term liver retention of $Pu^{239}$ increased as dose level decreased. Quantitative analysis showed that the plutonium injected was at least 98 per cent Pu(IV) and not more than 2 per cent Pu(VI). (auth)

**10320** THE SKELETAL TOXICITY OF $Pu^{239}$ IN ADULT BEAGLES. W. S. S. Jee, Betsy J. Stover, G. N. Taylor, and W. R. Christensen (Univ. of Utah, Salt Lake City). Health Phys., 8: 599-607(Dec. 1962).

Intravenous injections of 2.8, 0.90, 0.30, and 0.096 μc $Pu^{239}$/kg induced 7/9, 12/12, 12/12, and 7/8 bone cancers in adult beagles. The average accumulated rads to the skeleton varied from 326 ± 70 to 6470 ± 1590. The osteogenic sarcomas appeared later at lower dose levels and absorbed skeletal radiation doses. Multiple primary osteogenic sarcomas varied from 0 to 7 tumors/dog. Sixty-eight per cent of the tumors originated from the spongiosa of extremities (36.7 per cent) and the vertebral column (32.7 per cent). A total of 93.9 per cent (92/98) tumors arose from spongy bone, while only 6.1 per cent (6/98) originated from cortical bone. The anatomical distribution of osteogenic sarcomas differed for each dose level. A fibrosarcoma and a squamous cell carcinoma involving the skeleton were detected in the 0.096 μc/kg group. Radiochemical analyses of individual bones showed extreme variation in plutonium concentration from bone to bone and within individual bones. The skeleton exhibited extensive gross tissue damage in the higher dose levels, while only isolated empty lacunae in trabeculae and canal plugs and loss of osteocytes in cortical bone were observed in the 0.096 μc/kg group. The relationship of gross tissue damage to bone tumor production is discussed. (auth)

**10321** RETENTION, TRANSLOCATION AND EXCRETION OF INHALED $Pu^{239}O_2$. W. J. Bair, D. H. Willard, J. P. Herring, and L. A. George, II (General Electric Co., Richland, Wash.). Health Phys., 8: 639-49(Dec. 1962).

Beagle dogs were given single exposures to one of seven $Pu^{239}O_2$ aerosols that differed in particle size from 0.2 to 7.6 μ mass median diameter (MMD). Translocation of plutonium to other tissues and excretion in both urine and feces up to a month after exposure were greatest for dogs exposed to aerosols with the smallest median diameter. Dogs exposed to an aerosol with a MMD of 4.3 μ were studied for about 10 months. The half-time for retention of $Pu^{239}$ in lungs was about 300 days; however, during this period there was continuous accumulation of $Pu^{239}$ in bronchial lymph nodes, which resulted in about a 1500 to 1800 day half-time for total body retention of plutonium. Inhaled and intravenously injected plutonium nitrate (0.2 N $HNO_3$) were compared in still other dogs. After inhalation, 70 per cent of the body burden was in the lungs, 10 per cent in the liver and 15 per cent in bone. After intravenous injection, more than 80 per cent of the body burden was in liver and about 6 per cent each in the spleen and bone. The rate of excretion in urine was about five times greater after inhalation than after intravenous injection. Corresponding differences were observed in the levels of plutonium in blood. The results of these studies emphasize the importance of the chemical form and the particle size of inhaled plutonium aerosols on retention, translocation and excretion, and point out the problems to be encountered in estimating the body burden from excretion analysis. (auth)

**10322** ACUTE AND CHRONIC TOXICITY OF INHALED PLUTONIUM IN DOGS. J. F. Park, D. H. Willard, S. Marks, J. E. West, G. S. Vogt, and W. J. Bair (General Electric Co., Richland, Wash.). Health Phys., 8: 651-7 (Dec. 1962).

Beagle dogs were given single exposures to $Pu^{239}O_2$ aerosols. Deposition of 0.9 to 0.1 μc/g of lung caused death in 31 dogs in 55 to 412 days after exposure. Average radiation dose to lungs was 4000-14,000 rads. Lymphopenia, polypnea, weight loss and bradycardia developed prior to death. Gross and histopathologic tissue changes were limited to the lungs and associated lymph nodes, which contained 99 per cent of the plutonium content of the dog. One dog died 862 days following deposition of approximately 0.05 μc/g of lung. Dogs exposed to lesser quantities of plutonium appear normal 2 to 2½ years after exposure except for lymphopenia. (auth)

**10323** THE EFFECT OF INHALED $Pu^{239}O_2$ ON THE LIFE SPAN OF MICE. W. J. Bair, A. D. Wiggins, and L. A. Temple (General Electric Co., Richland, Wash.). Health Phys., 8: 659-63(Dec. 1962).

Approximately 800 mice, divided into four age groups varying from 122 to 369 days, were given single exposures to $Pu^{239}O_2$ aerosols. Each age group was separated into a control and five subgroups, containing different amounts (0.038-0.72 nc) of $Pu^{239}$ in the lung. The mean age at time of death was established for each subgroup. Comparison

of $Pu^{239}$-exposed mice with controls indicated no significant shortening of life span. No malignant tumors were seen. (auth)

**10324** DISTRIBUTION OF THE TRANSURANIC ELEMENTS IN MAMMALS. Patricia W. Durbin (Univ. of California, Berkeley). Health Phys., 8: 665-71(Dec. 1962). (UCRL-10282)

The biological behavior of the actinide elements is reviewed, particularly in relation to their chemical properties, and compared to the biological and chemical behavior of the lanthanide elements. An appendix compares the fine structure of the distribution of these elements in bone, as revealed autoradiographically. (auth)

**10325** SOME ASPECTS OF THE COMPARATIVE METABOLISM OF PLUTONIUM AND AMERICIUM IN RATS. D. M. Taylor (Royal Cancer Hospital, London). Health Phys., 8: 673-7(Dec. 1962).

The distribution of $Pu^{239}$ and $Am^{241}$ in the bones and tissues of rats was compared following intravenous or oral administration of the nuclides in several different chemical forms. Both $Pu^{239}$ and $Am^{241}$ were deposited extensively in the skeleton in approximately equal quantities, but in the liver the concentration of $Am^{241}$ was 5–10 times greater than that of $Pu^{239}$. The rate of removal of $Am^{241}$ from the plasma was more rapid than that of $Pu^{239}$, and this difference was reflected in the rate of uptake of these nuclides into the proximal, distal, and shaft regions of the femur. (auth)

**10326** TRANSFER OF SOME TRANSURANIC ELEMENTS TO MILK. R. O. McClellan, H. W. Casey, and L. K. Bustad (General Electric Co., Richland, Wash.). Health Phys., 8: 689-94(Dec. 1962). (HW-SA-2589)

The transfer of $Ca^{45}$, $U^{233}$, $Np^{237}$, $Pu^{239}$, $Am^{241}$, and $Cm^{244}$ from plasma to milk following a single intravenous dose was studied in mature sheep. The rates of plasma clearance of the radionuclides in decreasing order were $U^{233}$, then $Cm^{244}$, $Am^{241}$, and $Ca^{45}$ grouped together, followed by $Pu^{239}$ and $Np^{237}$. Plasma concentration of $U^{233}$, $Am^{241}$, and $Cm^{244}$ showed an initial decline followed by a slightly increased concentration at 7 hr and then a continuous decline for the remainder of the 10-day study. The plasma concentration of $Np^{237}$ at 1 hr was less than that noted at 2 and 4 hr post-injection. On the basis of their milk:plasma ratio, the radionuclides were placed in three groups: $Ca^{45}$ with a ratio of 10 to 40; $Cm^{244}$ and $Am^{241}$ with ratios of 2 to 5; and $U^{233}$, $Np^{237}$, and $Pu^{239}$ with ratios of 0.02 to 0.15. (auth)

**10327** REMOVAL OF PLUTONIUM FROM BLOOD AS A FUNCTION OF DTPA TREATMENT AND OF THE PHYSICAL STATE OF THE PLUTONIUM. Arthur Lindenbaum, John F. Markley, and Marcia W. Rosenthal (Argonne National Lab., Ill.). Health Phys., 8: 695-7(Dec. 1962). (TID-16264)

Monomeric and polymeric plutonium solutions were injected intravenously into rats. Polymeric plutonium disappeared from the plasma faster than the monomeric form (e.g., at 1½ hr, the plasma contained 23 per cent of the injected polymeric plutonium versus 34 per cent of the monomeric form). DTPA, given intraperitoneally 30 min after plutonium, reduced the plasma content of both forms to about 12 per cent of injected plutonium at 1½ hr, although the removal of the monomeric form was faster. The ultrafiltrate from plasma of untreated rats after injection of either form contained less than 0.01 per cent of injected plutonium over the first 24 hr. After DTPA treatment, more of the monomeric than of the polymeric plutonium was ultrafilterable (e.g., 36 per cent versus 8 per cent at 3 hr). (auth)

**10328** LIVER INJURY IN BEAGLES WITH $Pu^{239}$: DISTRIBUTION, DOSAGE AND DAMAGE. Terence H. Cochran, Webster S. S. Jee, Betsy J. Stover, and Glenn N. Taylor (Univ. of Utah, Salt Lake City). Health Phys., 8: 699-703(Dec. 1962).

The livers of $Pu^{239}$-injected beagles retained 15 to 30 per cent of the injected dose. Initially, autoradiographs showed a uniform distribution of $\alpha$-activity. At 400 days post-injection, there was a focal distribution associated with condensed reticulum and reticulo-endothelial concentration. Subsequently, at the time of sacrifice 3 to 8 years post-injection, 60 to 85 per cent of the liver was replaced by regenerative nodules with no $\alpha$-activity. The absence of hepatomas was in sharp contrast to the presence of osteogenic sarcomas in some dogs with comparable doses to bone and liver. (auth)

**10329** PATTERN OF LONG TERM SKELETAL REMODELING REVEALED BY RADIOAUTOGRAPHIC DISTRIBUTION OF $Pu^{239}$ IN DOGS. J. S. Arnold and W. S. S. Jee (Univ. of Utah, Salt Lake City). Health Phys., 8: 705-7 (Dec. 1962).

The detailed distribution of plutonium in the skeleton of the dog, and its redistribution as a function of post-injection time is described. The pronounced effect of plutonium dose level on the redistribution process is explained in terms of the varying type and degree of radiation damage incurred. (auth)

**10330** THE FAILURE OF PLUTONIUM TO DEPOSIT IN THE OSTEOID OF RACHITIC RATS. W. S. S. Jee and J. S. Arnold (Univ. of Utah, Salt Lake City). Health Phys., 8: 709-11(Dec. 1962).

A detailed radioautographic study of rachitic rats injected with plutonium(IV) citrate demonstrated that plutonium passed readily through the uncalcified osteoid and deposited on the underlying calcified bone surfaces. Other observations suggest that a small fraction of the plutonium was bound to the organic matrix. (auth)

**10331** STUDIES ON THE MECHANISM OF PLUTONIUM UPTAKE BY BONE. Harry Foreman (Los Alamos Scientific Lab., N. Mex.). Health Phys., 8: 713-16(Dec. 1962).

A study was undertaken to investigate the mechanism of uptake of plutonium by bone. The principal technique used was one which has gained wide acceptance in investigating bone chemistry—namely, in vitro uptake studies. Various bone fractions were shaken with $Pu^{4+}$ in a lactate buffer solution and the uptake rates were determined. The mineral phase of bone, both as ash (prepared in a muffle furnace) and as pure mineral (obtained by alkali treatment), took up greater quantities of plutonium and at faster rates than did organic fractions. Other quantitative studies indicated that this uptake was most likely to be surface adsorption. The uptake was not influenced by $Ca^{2+}$ or $Na^{+}$ in solution, indicating that the plutonium uptake could not be an ion exchange with surface cations as happens with uranium. To determine the implications of these findings when applied to the body situation, various bone fractions were implanted in the peritoneal cavities of rats, where the bone fractions could be bathed by tissue fluids. The results paralleled the in vitro findings; bone mineral strongly took up plutonium, but organic fractions did not. These studies suggest that plutonium is deposited by adsorption on bone mineral surfaces along capillary routes. (auth)

**10332** PRELIMINARY REPORT ON THE SITE OF LOCALIZATION AND POSSIBLE BINDING AGENT FOR

YTTRIUM, AMERICIUM AND PLUTONIUM IN CORTICAL BONE. G. M. Herring, Janet Vaughan, and Margaret Williamson (Churchill Hospital, Oxford). Health Phys., 8: 717-24(Dec. 1962).

Characteristics of bone surfaces are discussed in relation to the uptake of bone-seeking isotopes. The alkaline earths are concentrated behind the osteoid border of active surfaces. Yttrium, americium, and plutonium are concentrated on quiescent and resorbing surfaces; traces only occur in and beneath the osteoid border. In view of evidence of mucoproteins at sites where the latter elements are found in concentration, a separation of the mucoproteins in cortical bone was undertaken. Mucosubstances have been isolated which give the same reaction with certain reagents as the bone surfaces in question. One of these, a sialoprotein, might be expected, in view of its acidic nature, to be capable of metal binding. (auth)

**10333** PRINCIPLES AND TRENDS IN THERAPEUTIC REMOVAL OF INTERNALLY DEPOSITED RADIONUCLIDES. A. Catsch (Kernforschungszentrum, Karlsruhe, Ger.). Health Phys., 8: 725-30(Dec. 1962).

The general principles governing the therapeutical removal of radiometals by chelating agents are outlined. Experimental data are presented demonstrating the dependence of chelate effectiveness on the number and the nature of ligand atoms as well as on the molecular configuration of the ligand. Implications derived from experimental data and from the multicompartmental nature of a body organ for working out an optimal dosage schedule are discussed. (auth)

**10334** PRELIMINARY EVALUATION OF SEVERAL CHELATING AGENTS FOR PLUTONIUM REMOVAL. J. E. Ballou (General Electric Co., Richland, Wash.). Health Phys., 8: 731-4(Dec. 1962).

Preliminary tests indicate the chelating agent triethylenetetraminehexaacetic acid (TTHA) is as effective as diethylenetriaminepentaacetic acid (DTPA) in plutonium removal. TTHA appears to be even more effective than DTPA when the agents are administered orally. The range of toxicity and the optimum dosage levels of TTHA have not yet been clearly defined. Two additional chelating agents, aminoethylcyclohexyldiaminepentaacetic acid (ACHDPA) and aminoethoxycyclohexylaminetetraacetic acid (ACHTA), although structurally similar to DTPA, were considerably less effective than DTPA in plutonium removal. (auth)

**10335** THE EFFECT OF DIETHYLENETRIAMINE-PENTAACETIC ACID (DTPA) ON ACCELERATION OF EXCRETION OF ACTINIDE ELEMENTS. Harry Foreman (Los Alamos Scientific Lab., N. Mex.). Health Phys., 8: 735-7(Dec. 1962).

Whole-body counting was used to determine the effectiveness of DTPA in hastening the excretion of americium when the drug was given orally as compared to parenteral administration, when treatment was delayed after various periods of time, and when the radioisotope was deposited in the lungs. The experiment was stopped after 50 days. Oral treatment, while not as effective as parenteral treatment, was still surprisingly effective. The drug did significantly lower the body burden of the radioisotope deposited in the lungs. (auth)

**10336** THERAPEUTIC REMOVAL OF PLUTONIUM IN HUMANS. W. D. Norwood (General Electric Co., Richland, Wash.). Health Phys., 8: 747-50(Dec. 1962). (HW-SA-2567)

Associated with the production and fabrication of $Pu^{239}$ is the hazard of its entry into the body through inhalation or breaks in the skin. It is not possible to estimate, with any degree of accuracy, the amount of residual plutonium in the lungs when it is very insoluble. Bone is considered the critical organ for soluble $Pu^{239}$, while damage to the lungs presents the greatest hazard from insoluble $Pu^{239}$. However, poorly soluble $Pu^{239}$ may concentrate in peribronchial lymph nodes where it constitutes a distinct hazard. Certain slightly soluble $Pu^{239}$ compounds deposited in subcutaneous tissue may cause fibrosarcomas. If we may extrapolate from mice to man, this hazard to soft tissue could be considered comparable to the hazard to bone. Deposits of plutonium or its compounds in subcutaneous tissue should, therefore, be removed as thoroughly as possible by decontamination procedures, including surgery. The elimination rate of $Pu^{239}$ from the body by urinary excretion is increased by a factor of 50 to 100 by the intravenous administration of DTPA. It is recommended that DTPA be administered as quickly as possible following any incident in which it is expected that the maximum permissible deposition will be exceeded. DTPA is less effective when given orally than when administered intravenously. When therapy is continued for long periods, effectiveness decreases markedly, but effectiveness returns again after therapy has been stopped for several months. (auth)

**10337** REMARKS ON THE MAXIMUM PERMISSIBLE DEPOSITION OF PLUTONIUM IN MAN, AND THE SAFETY FACTORS IN THE PIVOT POINT RADIATION PROTECTION GUIDE OF 0.1 μc OF RADIUM IN MAN. Robley D. Evans (Massachusetts Inst. of Tech., Cambridge). Health Phys., 8: 751-2(Dec. 1962).

The relationship between the maximum permissible deposition of plutonium in man and the experience with radium deposition in man is described, with emphasis on the hidden safety factors in the radium limit which are, in turn, reflected in the plutonium limit. (auth)

**10338** THE LOS ALAMOS SCIENTIFIC LABORATORY'S EXPERIENCE WITH PLUTONIUM IN MAN. W. H. Langham, J. N. P. Lawrence, Jean McClelland, and L. H. Hempelmann (Los Alamos Scientific Lab., N. Mex.). Health Phys., 8: 753-60(Dec. 1962). (LADC-5360)

A historical account is presented of the Los Alamos Scientific Laboratory's industrial medical experience with exposure of personnel to $Pu^{239}$. Observations cover the period from the beginning of the Manhattan Project through 1960. In the early days, exposures were of an acute or semiacute nature. Improved industrial hygiene and engineering methods have changed the problem to one of chronic low-level exposure, largely via inhalation. Consideration of the Laboratory's experience during the past 17 years suggests that the present problem areas are the diagnosis of body burden under chronic exposure conditions and with little or no specific index of exposure other than a persistent low-level urinary excretion rate, and the choice of the critical organ when exposure is largely via chronic low-level inhalation. (auth)

**10339** COMPARISON OF URINARY EXCRETION DATA FROM SELECTED PLUTONIUM EXPOSURE CASES AT HANFORD. F. Swanberg, Jr. (General Electric Co., Richland, Wash.). Health Phys., 8: 761-5(Dec. 1962). (HW-SA-2579)

Eight case histories relating observed plutonium excretion rate data are presented. These data were selected from the records of Radiation Protection Operation at Hanford to show the effects of individual differences on mathematical expressions describing the excretion rate of the radionuclide as a function of time. Both inhalation and injection modes of entry are considered, with particular emphasis on the inhalation mode. (auth)

**10340** MAJOR SOURCES OF ERROR IN INTERPRETING URINALYSIS DATA TO ESTIMATE THE BODY BURDEN OF $Pu^{239}$: A PRELIMINARY STUDY. W. S. Snyder (Oak Ridge National Lab., Tenn.). Health Phys., 8: 767-72(Dec. 1962).

Several methods of estimating the body burden of $Pu^{239}$ from urinalysis data have been reported, and two of these have been coded for a digital computer. Intercomparison indicates that uncertainty by a factor of two or more may be present in some of these methods. The code PUQUAE has been tested, using data on hospital patients following a single intravenous injection of $Pu^{239}$. When a continuous rate of excretion curve is determined for each patient, the code estimates the intake to within some 30 per cent. It is concluded that individual variation, spacing of intake between sample dates, and the use of a true rate of excretion curve as opposed to a formula predicting discrete daily excretions are major sources of uncertainty in this method. While the data obtained are suggestive, the number of cases and hypotheses tested is small, and a firm estimate must be based on more extensive data. (auth)

**10341** THE ANEMIA OF LEUKEMIA. E. J. Walter Bowie, Joseph M. Kiely, W. Newlon Tauxe, and J. M. Stickney (Mayo Clinic and Mayo Foundation, Rochester, Minn.). J. Nucl. Med., 3: 423-35(Nov. 1962).

The anemia in 14 cases of leukemia was studied with combined radioiron and radiochromium technics. The data obtained in the eight cases of acute leukemia support the conclusion that anemia occurs in acute leukemia because the bone marrow is unable to compensate for the increased destruction of erythrocytes. Blood loss in the stools is not a significant factor in the production of the anemia. The in vivo and postmortem studies in two cases gave evidence of primary deposition of iron in the liver. Treatment with an antimetabolite restored to normal the erythrokinetics in one case of acute leukemia. Evidence of impaired erythropoiesis was found in two of the three cases of chronic granulocytic leukemia. In two cases of chronic granulocytic leukemia the plasma volumes were high. This suggests that there may be an element of hemodilution in the anemia of this disease. (auth)

**10342** THE USE OF IODINE-132 TO STUDY THYROID FUNCTION FOLLOWING THERAPY WITH IODINE-131. Ralph R. Cavalieri and E. Richard King (U. S. Naval Hospital, Bethesda, Md.). J. Nucl. Med., 3: 436-44(Nov. 1962).

A practical method is described for using $I^{132}$ for the measurement of thyroid uptake in patients soon after therapy with $I^{131}$. The application of this technique in six patients is reported. (C.H.)

**10343** CALIBRATION OF THYROID UPTAKE SYSTEMS. John U. Hidalgo, Ted Bloch, and Samuel B. Nadler (Touro Infirmary and Tulane Univ., New Orleans). J. Nucl. Med., 3: 445-53(Nov. 1962).

Problems involved in the calibration of thyroid iodine-131 uptake measurements are reviewed. A method is described that employs a hollow lucite neck phantom with a hole provided for the insertion of test tube samples. The cylinder is filled with an ion exchange resin impregnated with enough mock iodine $Cs^{137}$-$Ba^{133}$ to provide a background count equivalent to the background in a typical normal patient after the administration of 10 $\mu$c of $NaI^{131}$. A second phantom provides a background count equivalent to that in a typical normal patient after the administration of 50 $\mu$c of $NaI^{131}$. Three sets of metal containers are provided with quantities of mock iodine in resin to stimulate various percents of the administered dose for doses of 50, 10, and 1 microcuries. A body phantom and a second neck phantom and cylinder are also used for the measurements. Good correlation with clinical results was demonstrated. (C.H.).

**10344** DETECTION OF BONE METASTASES IN SCANNING STUDIES WITH CALCIUM-47 AND STRONTIUM-85. K. R. Corey, P. Kenny, E. Greenberg, and J. S. Laughlin (Sloan-Kettering Inst. for Cancer Research, New York and Memorial Hospital for Cancer and Allied Diseases, New York). J. Nucl. Med., 3: 454-71(Nov. 1962).

The HEG scanning system, designed specifically for external counting of high energy gamma rays, was applied towards the diagnosis of bone metastases from breast carcinoma. Studies on six patients are described who had been given intravenous injections of either calcium-47 or strontium-85. In four of these cases there was no evidence of bone metastases and the radioisotope uptakes in a variety of bones were normal. Of particular interest in this work was the distribution of activity along the thoracic spine. With a straight hole collimator in the scanning head, the uptake was found to be fairly constant throughout, although, between the fifth and the ninth vertebrae, uptakes 10 to 30% larger than above or below were sometimes seen. Two patients had complaints of pain in the thoracic spine. Elevated uptakes were detected over the painful areas while radiographs were not reported to show bone lesions. The presence of metastases were confirmed in one case by surgery and in the other case after five months by radiographic examination. The scans of these and other lesions demonstrate that the HEG scanning system with its quantitative read-out has advanced the possibility of detecting and outlining bone lesions and also has made it possible to obtain more precise data on the calcium turnover in the lesions. The scanning technique and the clinical implications of the findings are discussed. (auth)

**10345** ABSORPTION AND EXCRETION OF RADIOACTIVE $Hg^{203}$ MERCAPTOMERIN SODIUM IN HUMANS. Benjamin Calesnick and Arthur Wase (Hahnemann Medical Coll., Philadelphia). J. Nucl. Med., 4: 29-34(Jan. 1963).

Radioactivity was detected in the plasma for 48 hours when $Hg^{203}$ mercaptomerin sodium was administered subcutaneously to patients in cardiac failure. In the presence of renal disease, it was detected in 7 days. Normally 72% of the administered dose was recovered in the urine during the first 24 hours. A dissociated relationship exists between $Hg^{203}$ excretion and the diuretic response. (auth)

**10346** THE TOXICITY OF PLUTONIUM DEPOSITED IN SKELETAL TISSUES OF BEAGLES. I. THE RELATION OF THE DISTRIBUTION OF PLUTONIUM TO THE SEQUENCE OF HISTOPATHOLOGIC BONE CHANGES. Webster S. S. Jee and James S. Arnold (Univ. of Utah, Salt Lake City). Lab. Invest., 10: 797-825(July-Aug. 1961).

The relation of the distribution of Pu to the sequence of histopathologic bone changes was studied using autoradiographic, microradiographic, histopathologic, and vascular injection techniques. Dogs were sacrificed from 1 to 1576 days following a single intravenous administration of 2.7 $\mu$c/kg of $Pu^{+4}$ citrate given at 14 to 18 months of age. Pu induced bone lesions by direct and indirect mechanisms. Early changes occurred in trabecular bone, resulting in a transverse plate in spongiosa, acellular marrow cavities, peritrabecular fibroses, abnormal bone resorption, and endosteal bone growth. Late changes affected cortical bone and were manifested by plugging of haversian canals, resulting in death of osteocytes, followed by disturbance in bone remodeling (large resorption cavities, bizarre-shaped and abnormally mineralized osteones), eroded periosteal surfaces, and fibroses and spontaneous fractures. The late effect was the induction of osteogenic sarcomas. (H.H.D.)

**10347** CONCENTRATION OF RADIOSTRONTIUM IN THE BLOOD AND BONES OF RATS WITH RESPECT TO THE SEX AND THE AGE. M. Rossi-Torelli and E. Tarani (Centro Applicazioni Militari Energia Nucleare, Pisa, Italy). Minerva Nucl., 6: 243-6(Sept. 1962). (In Italian)

The following data were obtained in rats during the first 24 hours after the intraperitoneal injection of $Sr^{85-89}$: (a) the sex did not influence the uptake and turnover of the radioisotope in the blood; (b) a relationship was demonstrated between the weight (age) of the animals and the proportion of Sr found in the blood stream from the first hours of treatment, i.e., a smaller proportion of the injected dose of Sr was found in the blood of young animals than in that of older animals. Furthermore, young animals excrete Sr more rapidly during the first 4 to 5 hours but accumulate a greater amount in the bone tissue in a shorter time. (auth)

**10348** BEHAVIOR OF THE BONE METABOLISM OF $Sr^{85}$ AND $Sr^{89}$ IN RATS TREATED WITH ANDROGENIC STEROIDS. R. Cattaneo and P. Sibilla (Università, Milan). Radiobiol. Latina, 4: 303-9(Oct.-Dec. 1961). (In Italian)

Two groups of growing rats were injected with 2 $\mu$C/100 g of body weight of $Sr^{85}$ and $Sr^{89}$ followed by a three-day treatment of 5 mg/100 g of testosterone. Radioactivity was evaluated on femurs divided into epiphyses, metaphyses and diaphyses; no relevant change was established in treated rats as compared to controls. The fixation of radioelements was greatest in the metaphysis followed by the epiphysis and the diaphysis. (auth)

**10349** CONCENTRATION OF RADIOACTIVITY PRESENT IN THE PRINCIPAL SPECIES OF EATABLE FISH FROM LAKE MAGGIORE. Adolfo Pugliese (Comitato Nazionale per l'Energia Nucleare, Rome and Università, Milan). Rend. Ist. Lombardo Sci. Lettere, B, 95: 216-31 (1961). (RT/BIO(62)33) (In Italian)

During the spring 1959 (before the nuclear reactor Ispra-I started its work), fish samples from five fishing-zones of the Lago Maggiore were collected. From each fishing-zone samples of 10 eatable fish species were selected. Using suitable radiochemical methods, total beta radioactivity, $Sr^{90}$, and $Cs^{137}$ concentration were measured. No differences in the radioactivity concentration were found between the 5 fishing zones, while significant differences were noted between the different fish species. Moreover some connection may be observed between $Cs^{137}$ concentration and feeding habits of fishes. The fishes of the Lago Maggiore were found to have a general mean content of 470 pc of $Cs^{137}$ and of 57 of $Sr^{90}$ per kilogram of body weight. (auth)

**10350** SUCCESSIVE GENERATION RAT FEEDING STUDIES WITH A COMPOSITE DIET OF GAMMA-IRRADIATED FOODS. Merrill S. Read (U. S. Army Medical Research and Nutritional Lab., Denver), Herman F. Kraybill, William S. Worth, Samuel W. Thompson, II, Gerhard J. Isaac, and Norman F. Witt. Toxicol. Appl. Pharmacol., 3: 153-73(Mar. 1961).

Four successive generations of rats were fed irradiated (5.58 megarad) or nonirradiated diets compounded from 9 frozen-stored foods plus a nonirradiated vitamin supplement. A significantly decreased rate of growth of 4th-generation females fed the irradiated diet was probably due to marginal nutritional inadequacy. Reproductive performance, life span, and incidence of disease were not significantly affected by radiation processing of the food. Similarly, metabolizable energy value of the diets as well as percentage of availability of the macronutrients were not altered. Availability of carbohydrate was higher in adult animals than in the same animals as weanlings, regardless of diet treatment. Of 6 liver and blood enzymes assayed, only liver cytochrome oxidase activity was altered as a result of consumption of the irradiated diet. The results are explained on the basis of radioinduced destruction of the unsaturated fatty acids. However, a previously reported concomitant decline in hypotonic endogenous respiration was not observed. This, coupled with normal phosphatase activity, suggests that the altered cytochrome oxidase activity may not be related to essential fatty acid destruction. (H.H.D.)

**10351** TRANSLOCATION OF THORIUM DAUGHTERS TO BONE. L. D. Marinelli and H. F. Lucas, Jr. (Argonne National Lab., Ill.). p.499-516 of "Some Aspects of Internal Irradiation." Oxford, Pergamon Press, 1962. (TID-13790)

An attempt was made to correlate the $Th^{232}$-$Ra^{228}$ and $Th^{228}$ values found in skeletal specimens of patients injected with known amounts of thorotrast with the radioactive equilibrium of the chain in the reticuloendothelial system (R.E.S.). The data for $Ra^{228}$ are in accord with the predictions of Reynolds et al., for values of the retention parameter $0.2 < b < 0.5$. No excess of skeletal $Th^{228}$ is found to justify the assumption that washout $Th^{228}$ translocates from the R.E.S. to bone mineral. No data for actual $Ra^{224}$ in bone are available, but whole-body and excreta activity measurements are consistent with the assumption that $Ra^{224}$ is retained in the skeleton to a greater extent than $Ra^{228}$. Reliable direct measurements of this isotope are needed to establish with greater precision the chronic absorbed dose to the skeleton. (auth)

**10352** FACTORS INFLUENCING STRONTIUM-90 IN MILK FROM THE BRAINERD, MINN. MILKSHED. (Public Health Service, Washington, D. C.). Environmental Health Series, Radiological Health. Public Health Service Publication No. 999-R-1. Dec. 1962. 79p. Free.

A study was undertaken to investigate consistent farm-to-farm differences in the concentrations of strontium-90 found in milk produced within a small milkshed in central Minnesota. Covering an 8-month period, the study included sampling of milk, hay, grain, silage, water, forage, soil, and precipitation. The data indicate that 70 to 90% of the cattle's strontium-90 intake came from the native grass hay and that the farm-to-farm differences of strontium-90 concentrations in milk correspond to similar differences of strontium-90 concentrations in the hay fed. On the basis of the data obtained, it is not possible to explain why the consistent differences in the native grass hay existed. (auth)

## Radiation Effects on Living Tissues

**10353** (BNL-6098) THE BIOLOGICAL EFFECTS OF HEAVY COSMIC RAY PARTICLES. H. J. Curtis (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT-30-2-GEN-16]. 19p.

A very narrow beam of 22-Mev deuterons was developed which will produce the same effect in biological material as a track from a heavy primary cosmic ray particle. Using this microbeam on mice, it was concluded that these cosmic particles will have the following biological effects on man: There will be no effect in the brain since this tissue is very insensitive to this radiation; minute opacities may form in the lens of the eye but these will not progress to form a cataract; dark hair will turn gray; and other organs will probably be unaffected. (auth)

**10354** (BNL-6105) LEUKEMOGENIC EFFECT OF WHOLE BODY $Co^{60}$-$\gamma$-IRRADIATION COMPARED WITH $H^3$-THYMIDINE AND $H^3$-CYTIDINE: PRELIMINARY REPORT ON THE DEVELOPMENT OF THYMIC LYMPHO-

MAS IN C$^{57}$BL/6J MICE. H. Cottier, E. P. Cronkite, E. A. Tonna, and N. O. Nielsen (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT-30-2-GEN-16]. 13p.

Groups of 32 female mice 6 weeks of age were given a total of 480 r whole-body-Co$^{60}$-γ-irradiation in increments of 160 r at 7 day intervals and at a dose rate of 22 r/min, or three subcutaneous injections of H$^3$-thymidine (3 × 10 μc/g body weight; specific activity 1.9 C/mM) at weekly intervals, or three subcutaneous injections of H$^3$-cytidine (3 × 10 μc/g body weight; specific activity 1 C/mM) at weekly intervals, or three subcutaneous injections of both H$^3$-thymidine and H$^3$-cytidine (dosage as mentioned) at weekly intervals, or no treatment. The mice were followed for 250 days. Only Co$^{60}$-γ-whole-body-irradiated mice developed thymic lymphomas. The difference is statistically significant. These experiments will be helpful in determining the possible hazards involved in the use of these radioactive compounds and also may lead to a better understanding of basic phenomena underlying radiation leukemogenesis and cancerogenesis, since H$^3$TDR gives predominantly intranuclear radiation and H$^3$CR predominantly cytoplasmic irradiation. (auth)

**10355** (BNL-6113) CELL POPULATION STUDIES ON THE INTESTINE OF CONTINUOUSLY IRRADIATED RATS. Doris R. Wimber and Leonard F. Lamerton (Brookhaven National Lab., Upton, N. Y. and London. Royal Cancer Hospital. Inst. of Cancer Research). [1962]. Contract [AT-30-2-GEN-16]. 20p.

Rats were exposed for 5 days to doses of 84, 176, and 415 rads/day γ radiation. Intestinal injury was determined by examination of whole-crypt squashes for total cell population, the number of cells in mitoses, and the number of cells labeled with H$^3$-thymidine after a single injection. An increase in the incorporation of H$^3$-thymidine into the nuclei of the intestinal epithelium was observed after exposure to 415 rads/day. (C.H.)

**10356** (BNL-6546) FUNDAMENTAL PROBLEM OF LATE NEUROLOGICAL EFFECT FOLLOWING ACUTE IRRADIATION. Y. L. Yamamoto (Brookhaven National Lab., Upton, N. Y.). Oct. 26, 1962. Contract [AT-30-2-GEN-16]. 39p.

The radiation effect on RNA metabolism in the mature central nervous system, using tritiated cytidine as a precursor for RNA synthesis with autoradiographic method, is observed in a depression of the labeling of cytoplasmic RNA in the choroid plexus cells, pyramidal cells (Rose's area $h_3$) in Hippocampus, neurons in the third layer of the postcentral cortex and Purkinje cells of the cerebellum as early as 24 hours to 48 hours following a single dose of 500 r x ray (250 kv) irradiation to the rat's head. The increased labeling of RNA in the secretory cells of the supraoptic nuclei of the hypothalamus indicates a slight increase of RNA synthesis in all subcellular compartments of the neuron, particularly in the nuclei following irradiation, even in a dose of 500 r to the head only. However, the marked depression of the cytoplasmic RNA labeling in the other neurons following ionizing radiation, which appears as early as 24 to 48 hours following irradiation, suggests that the ionizing radiation can directly induce a depression of cytoplasmic RNA synthesis and hence the neuronal activity. The experiment using a physiochemical method has clearly shown that the decrease of cytoplasmic RNA labeling, and presumably synthesis, can be detected as early as 24 hours to 48 hours, without any cellular alteration, after radiation as low as 500 r to the rat's head. Therefore, the decrease of the cytoplasmic RNA is not necessarily a secondary effect due to regressive cellular alteration, but a direct radiation effect. (auth)

**10357** (BNL-6572) USE OF A DIGITAL COMPUTER IN THE DEVELOPMENT OF A POSITRON SCANNING PROCEDURE. James S. Robertson and Arcadio M. Niell (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT-30-2-GEN-16]. 20p.

The development of a multi-detector positron scanner for use in the localization of brain tumors after the administration of As$^{74}$ or Cu$^{64}$ is discussed. A digital computer was used to analyze data from a 32-crystal scintillation detector system. (C.H.)

**10358** (BNL-6575) THE EFFECTS OF RADIATIONS OF DIFFERENT LET ON EARLY RESPONSES IN THE MAMMAL. J. L. Bateman and V. P. Bond (Brookhaven National Lab., Upton, N. Y.). Dec. 10, 1962. Contract [AT-30-2-GEN-16]. 30p.

The status of radiobiological investigations with fast neutrons is reviewed. The discussion includes the H$^3$(p,n)He$^3$ reaction as a source of fast neutrons, methods used in the exposure of small mammals to graduated neutron doses, and the relation of biological effectiveness to the linear energy transfer of radiations. Results are reviewed from studies in mice on the response of thymus weight, spleen weight, spermatogenesis, and nucleic acid synthesis to fast neutrons as a function of energy. Comparisons are made of the relative biological effectiveness of fast neutrons, x, and γ radiations. The reliability of dose-effect curves is discussed. (33 references.) (C.H.)

**10359** (HW-SA-2606) CELL CYCLE POPULATIONS AND MITOTIC INHIBITION FOLLOWING X-RADIATION. J. Van't Hof (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). [May 23, 1962]. Contract AT(45-1)-1350. 13p.

The decrease in cell division following x irradiation of pea seedlings was shown to be primarily the result of a block in the passage of cells going from the S to the $G_2$ interphase period. S period cells showed a temporary effect as measured by nuclear uptake of H$^3$-thymidine. The degree of blockage increased with dose as indicated by the delay in appearance of S period cells in mitosis. There was little correlation between the duration of effect on thymidine uptake and mitotic inhibition. (auth)

**10360** (TID-15850) THYMIC LYMPHOMA INCIDENCE AND LONGEVITY OF FEMALE MICE IRRADIATED WITH EITHER FISSION NEUTRONS OR Co$^{60}$ γ-RAYS AT DIFFERENT DOSE RATES. Howard H. Vogel, Jr. and Donn L. Jordan (Argonne National Lab., Ill.). Apr. 1962. Contract [W-31-109-eng-38]. 13p. (UAC-6296)

Thymic lymphoma was the chief cause of death of 82 mice exposed to either 100 rads fission neutrons or 200 rads γ radiation each week at 4 different dose rates. Eighty percent showed this pathology at autopsy between 90 and 221 days after the last exposure to either radiation. Results also strongly suggest a relationship between dose rate and life span for both radiations. (C.H.)

**10361** (TID-15852) SOME EFFECTS OF CHRONIC GAMMA IRRADIATION ON MOUSE TESTIS. B. R. Nebel, E. M. Coulon, and D. J. McWhinnie (Argonne National Lab., Ill.). Mar. 1962. Contract [W-31-109-eng-38]. 32p. (UAC-6297).

Mice exposed to 12, 24, 43, and 74 r gamma radiation per day were observed with reference to the following parameters and compared with controls: testis weights, testis areas in section, tubular areas in section, Chalkley counts on cell types and on empty space within and surrounding the tubules, and special counts of type A and intermediate spermatogonia, type B spermatogonia, and leptotene spermatocytes. The results show that under prolonged gamma

irradiation testis weights decrease concomitantly with the loss of spermatogenic cells from the tubules. Measurements of cross sectional areas of testes and tubules were found to decrease along with testis weight. There is an increase in the relative area occupied by the Sertoli cells surviving the gamma doses, because of decreasing tubular dimensions. Spermatogonia under 12 and 24 r/day survive with low levels of mitotic activity. At higher intensities they do not survive beyond 2000 r cumulated dose. Spermatocytes vanish due to lack of recruitment as well as through irradiation death. Their disappearance time is intensity-dependent. The same is true of spermatids and spermatozoa. (auth)

**10362** (TID-16254) CHRONIC GAMMA IRRADIATION OF A PITCH PINE-OAK FOREST—ITS PHYSIOLOGICAL AND GENETICAL EFFECTS ON SEXUAL REPRODUCTION. François Mergen and G. R. Stairs (Yale Univ., New Haven. School of Forestry). June 25, 1962. Contract [AT(30-1)-2755]. 35p.

Results are reported from studies of the detrimental effects of chronic low-level $\gamma$ exposure over a period of several years on the reproductive potentialities of a natural pine-oak forest. Pinus rigida and Quercus sp. trees growing in an area surrounding a $Co^{60}$ radiation field were used for the study. A decrease in cone length of pine trees was associated with an increase in the dose of $\gamma$ radiation accumulated by the trees. Decreased seed germination rate and seedling height were also observed. Visual aberrations were observed in flower morphology of oak trees. Internal abnormalities in acorn morphology and reduced percentage of survival and height of seedlings were also observed. (C.H.)

**10363** (TID-17676) FURTHER INVESTIGATIONS CONCERNING THE EFFECTS OF COSMIC RAY HEAVY NUCLEI AND OF MICROBEAMS ON MAMMALIAN SKIN. Progress Report for January 1, 1962–December 31, 1962. Herman B. Chase (Brown Univ., Providence). Dec. 27, 1962. Contract AT(30-1)-2018. 5p.

Histological examination of growing hair follicles from 1 to 96 hr after exposure to doses of x radiation between 200 and 2000 rads showed that a dose of 200 rads is subthreshold for subsequent greying and for temporary epilation. Nevertheless, at 20 to 24 hr damage to the hair bulb is pronounced and appears essentially equivalent to that following a dose of 2000 rads. At 36 hr there is recovery from the 200 rad dose and continued disorganization from the 2000 rad dose. It was concluded that 200 rads x radiation is a subthreshold dose only in terms of gross appearance of hair or in terms of histological appearance of the skin several days after exposure. A dose of 200 rads produces extensive tissue disorganization of the bulb and disorientation of melanocytes, but does not prevent rapid tissue recovery and subsequent normal differentiation of the hair and inner sheath. Rather than reflecting thresholds of damage, the data indicate that there are thresholds beyond which full recovery of tissue does not occur. Results of studies of the effects on skin of stripped carbon nuclei of 10-Mev/nucleon energy indicated a threshold for greying at 50 rads. Studies using a collimated electron beam with exposures to the skin through slits 200 microns wide gave additional evidence that the orientation of the slit relative to the slope of the hair follicle makes a difference in effect. Results are included from a study on the response of the melanoblast and melanocyte cells in the eyes of neonatal mice to 1000 r x radiation. By irradiating the eyes at different times following birth it was shown that the reduction in eye pigmentation is an extension of the radiosensitivity of the developing retina and is only an indirect effect on the associated epithelial melanocytes. The sequence of events in the hair growth cycle was investigated as part of a study on radioinduced epilation. (C.H.)

**10364** (TID-17690) STUDY OF THE MECHANISM OF ACTION OF IONIZING RADIATIONS ON THE GENETIC MATERIAL OF E. COLI K 12. A MUTATION OF YEAST RESISTANT TO IONIZING RADIATIONS. Progress Report. H. Marcovich (Institut Pasteur, Paris). [1962]. Contract AT(30-1)-2803. 7p.

Progress is reported in investigations of the nature of biochemical changes involved in the induction of mutations in Escherichia coli by exposure to x radiation, $\alpha$ particles, and ultraviolet light. Data are included from studies of the effects of ionizing radiations on genetic recombination in E. coli K12 and the response of E. coli to incorporated $P^{32}$. A mutant strain of E. coli is reported that is resistant to lethal effects of x, $\gamma$, and $\alpha$ rays, but not to mutagenic effects of these radiations or to ultraviolet light of $P^{32}$ decay. (C.H.)

**10365** (TID-17692) A STUDY OF THE EFFECT OF IONIZING RADIATION ON THE LIPID METABOLISM OF BLOOD AND BONE MARROW CELLS. Annual Progress Report, May 16, 1962–December 15, 1962. B. Malamos (Athens. Univ.). [June 19, 1962]. Contract AT(30-1)-2769. 24p.

Results are reported from studies on the effects of x radiation on the incorporation of acetate-1-$C^{14}$ into leukocyte lipids. Doses ranging from 2,500 to 15,000 r had no effect on incorporation of acetate into the lipids of leukocytes in vitro when incubation took place immediately after irradiation, while doses of 5,000 r seemed to produce a small inhibition of about 5%. (C.H.)

**10366** (TID-17697) A STUDY OF THE GENETIC AND BIOCHEMICAL EFFECTS OF RADIATION ON BACTERIA. Final Report, July 1, 1953–September 30, 1962. (Texas. Univ., Austin). Contract AT(40-1)-1649. 10p.

Progress is reported in studies of the genetic and biochemical effects of radiation on bacteria. Topics discussed include the effects of radiation on adaptation, pattern studies on the induced enzymes nitratase and $\beta$ galactosidase in a number of strains of irradiated E. coli, the contribution of various cell components to radiation injury, the effect of pigment and spore formation on radiosensitivity, and factors affecting radioresistance in Escherichia coli. Preliminary studies were made on the effects of radiation on biological processes in the soil. (C.H.)

**10367** (TID-17727) INTRAGASTRIC IRRADIATION WITH $Ru-Rh^{106}$: RESULTS IN PATIENTS WITH PEPTIC ULCERATIVE DISEASE AND WITH GASTRIC NEOPLASMS. Final Report. Robert C. Fruin, Margaret S. Littman, and Armand Littman (Illinois. Univ., Chicago. Coll. of Medicine). [1961]. Contract AT(11-1)-1079. 32p.

A small $Ru-Rh^{106}$ $\beta$ source mounted within a rubber balloon was used for intragastric irradiation of patients with peptic ulcerative disease and gastric neoplasm. Two patients with ulcerative disease developed typical radiation gastric ulcer after exposure to doses of 1000 rep or more. Doses of up to 2000 rep were given to 6 patients with gastric neoplasm without appreciable influence on the clinical course. (C.H.)

**10368** HEMATOPOIETIC STUDIES IN X-IRRADIATED NEWBORN RATS. George W. Cooper and Albert S. Gordon (New York Univ., New York). Acta Haematol., 25: 282-99 (1961).

In rats given 200 r on the 1st day of life, red cell counts, hemoglobin concentrations, and hematocrit values fell sharply to half the initial values by the 10th day, but recov-

ered rapidly. On the other hand, similarly irradiated adult rats showed only small depression in these values. The linear fall observed in the mean volume of the large fetal red cells of normal newborn rats was retarded by x radiation, and may represent an inhibition of x rays on the formation of additional smaller red cells of the adult variety. A very rapid and severe decrease occurred in the white cell counts of the irradiated adult and baby rats. Recovery was rapid in the adults, with essentially normal values attained by the 15th day. However, in the newborn animals, the return to control levels was delayed until the 40th day. The reduction observed in the numbers of circulating erythrocytes and leukocytes of the irradiated newborn rats paralleled the depletion noted in the cellular elements of the bone marrow. It was concluded that the greater sensitivity to x radiation of the hematopoietic processes of newborn animals is a reflection of their rapid growth rate, which imposes a greater burden on these processes than in the adult. The decrease observed in mean red cell volume with maturation in both normal and irradiated newborn animals supports the hypothesis of an abrupt transition from the production of the larger, fetal red cells to the smaller, adult type at about the time of birth. It was also concluded that the life span of the fetal red cell is relatively long, in comparison to the 65-day longevity of the adult red cell. (H.H.D.)

**10369** EFFECTS OF CELL-FREE SPLEEN EXTRACT TREATMENT ON HEMATOPOIETIC TISSUES OF IRRADIATED GUINEA PIGS. I. HISTOLOGICAL OBSERVATIONS. Friedrich Ellinger and Thomas A. Strike (Naval Medical Research Inst., Bethesda, Md.). Acta Haematol., 26: 117-27(1961).

Radioinduced histological changes were studied in the spleen and bone marrow of guinea pigs that were exposed to the $LD_{75/30}$ (650 r) of $Co^{60}$ gamma radiation and had received homologous or heterologous cell-free spleen extracts after irradiation. In both organs, postirradiation treatment with the spleen extracts accelerated the recovery from irradiation. Furthermore, it appears that the chain of events was the same with homologous (guinea pig spleen) or heterologous (mouse spleen) extract. It was concluded that the previously established reduction of radiation mortality by homologous as well as heterologous spleen extracts is due to a common mechanism. The cell-free spleen extracts also enhanced the natural recovery process in the blood-forming organs. The accelerated recovery process was due to a stimulatory effect of the spleen extract on the stem cells. Spleen extract treatment affected the radioinduced changes in spleen profoundly during the first week after irradiation, while the bone marrow changes were most significantly influenced at the beginning of the second postirradiation week. It is suggested that bone marrow recovery, at least to a certain extent, is subordinate to that of the spleen. With cell-free spleen extracts, the initial phase of radioinduced bone marrow effects remained entirely unchanged. A complete restitution was observed within 14 days in the spleen cell-treated animals, while in the untreated irradiated animals complete recovery was not attained before 21 days. The regeneration of both erythro- and myelopoietic tissue was accelerated. (P.C.H.)

**10370** EFFECTS OF CELL-FREE SPLEEN EXTRACT TREATMENT ON THE HEMATOPOIETIC TISSUES OF IRRADIATED GUINEA PIGS. II. HISTOLOGICAL OBSERVATIONS WITH ALKALINE PHOSPHATASE STAINING. Friedrich Ellinger and Thomas A. Strike (Naval Medical Research Inst., Bethesda, Md.). Acta Haematol., 26: 325-32(1961).

Guinea pigs were given whole-body $Co^{60}$ irradiation (650 r) and injected daily thereafter with cell-free extracts of homologous and heterologous spleen. Spleen of irradiated control guinea pigs showed a progressive reduction of alkaline phosphatase staining commencing after the 3rd postirradiation day and reaching a maximum on or about the 9th day. Treatment of the animals with spleen extracts modified the radioinduced changes in alkaline phosphatase staining, so that an almost normal appearance was noted over the entire 14-day observation period. Most of the alkaline phosphatase-staining spleen elements were mature neutrophils. It was concluded that spleen extract treatment affects apparently various cellular elements of spleen in a different way. The results support the hypothesis that protection of phosphorylization processes against effects of irradiation represent one of the mechanisms by which the radiation protective effect of spleen extracts is effected. (H.H.D.)

**10371** SERUM BUTANOL EXTRACTABLE IODINE (BEI) VALUES OF ADOLESCENTS EXPOSED IN UTERO TO THE ATOMIC BOMB IN NAGASAKI, JAPAN. Gerald N. Burrow, Howard B. Hamilton, and Evelyn B. Man (Atomic Bomb Casualty Commission, Hiroshima-Nagasaki). Am. J. Med. Sci., 243: 751-7(June 1962).

Attempts were made to ascertain the influence, if any, of ionizing radiation, at various stages of gestation, on adolescent thyroid function as evaluated by clinical examination and by measurement of the serum BEI. Blood samples for serum BEI determinations were obtained from 249 exposed and control children, all of whom were in utero August 9, 1945. Radiological determination of the number of epiphyseal centers closed in the hand and wrist indicated that the 15-year-old Japanese boys were not as mature as the girls. No statistically significant differences were demonstrated between the mean BEI values for exposed and control groups, although the values tended to be higher in exposed males and females. Although the mean BEI value for males was lower in a more heavily irradiated group, for the females it was slightly higher, and the difference was statistically significant only for the males. Thus in the first trimester children, where the mother's influence would seem to be greatest and the mean BEI values would be most affected, no significant differences were found. The data do not substantiate any hypothesis regarding a blast effect, since the values in the distal control group approximate those of the non-exposed migrant control group. (P.C.H.)

**10372** LATE IRRADIATION CHANGES IN VAGINAL CYTOLOGY. Raymond H. Kaufman, Nathan H. Topek, and John A. Wall (Baylor Univ., Houston, Tex.). Am. J. Obstet. Gynecol., 81: 859-66(May 1961).

Cytological studies were conducted, by conventional staining and fluorescence microscopy, on vaginal smears obtained from 124 patients 6 months to 25 yr after x-ray or radium therapy for gynecologic cancer. The results were compared with studies of smears from normal women. Evidence of protracted effects of irradiation on vaginal cells was obtained in 72% of the cases. Good late radiation change was found in 25% of the smears, of which 44% showed severe cellular atypism. All of the patients were clinically free of recurrent or persistent tumor. Smears showing late radiation change revealed the presence of predominantly basal and parabasal cells with a clean background relatively devoid of white blood cells. Cell clumping was prominent, with the cell borders in the clumps being indistinct and the nuclei being enlarged and irregular with a homogeneous appearance without chromatin clumping. Many of the nuclei assumed bizarre shapes and were hyperchromatic. Patients treated for cervical carcinoma showed the greatest degree of cytologic response as well as the severest degree of

cellular atypism. Length of time after treatment did not influence the relative degree of late radiation change. (P.C.H.)

**10373** PREPYRIFORM ELECTRICAL ACTIVITY AFTER 250 r WHOLE-BODY X IRRADIATION IN RATS. Fred Rosenthal and Paola S. Timiras (Univ. of California, Berkeley). Am. J. Physiol., 204: 63-7(Jan. 1963).

Evoked and spontaneous electrical activity was recorded from the prepyriform cortex of rats with permanently implanted electrodes. Evoked responses were obtained by lateral olfactory tract stimulation. Measurements of the electrical activity were made daily for 10 days before and after 250 r of whole-body x radiation. Radiation did not significantly alter spontaneous activity. On the other hand, irradiation produced a decrease in the latency of the evoked response and a reduction in the average voltage of the response to a test stimulus given 12 to 24 msec after a conditioning stimulus. The results were interpreted in terms of an increase in conduction velocity in the olfactory tract axons and a reduction of the action of prepyriform inhibitory elements after irradiation. (auth)

**10374** THE EFFECTS OF CATHODE-RAY IRRADIATION OF WHEAT ON SURFACE MOLDS; RESPIRATION, FLOUR FLAVOR AND ODOR, AND GERMINATION. M. G. Cropsey, C. M. Leach, Te May Ching, Lois A. Sather, and D. E. Wiant (Oregon State Univ., Corvallis). Ann. Appl. Biol., 50: 487-505(Sept. 1962).

The effects of cathode radiation were determined by irradiating kernels at different moisture levels, under different combinations of dosage (10600 to 2000000 rep) and voltage (600000 to 1,000,000 v) and on 1 or 2 sides. Kernels artificially inoculated with Aspergillus repens, a storage mold, showed that as dosage was increased there was a corresponding reduction of viable spore load, with some reduction even at the lowest dosage of 10600 rep. Irradiation of kernels at the highest applied voltage of 1000000, on 2 sides, and at high moisture level was the most effective in killing spores. Dosages above 42400 rep (total dosage at 600000 v) significantly reduced the total number of normal plants germinating from kernels irradiated on 1 or both sides or at high or low moisture levels. The same was true at 23000 rep (total dosage at 1000000 v). The thresholds for irradiated flavor and odor for flour milled from irradiated kernels were about 169600 rep (total dosage at 600000 v) and about 46000 rep (total dosage at 1000000 v), regardless of the moisture content or whether the dosage was applied on 1 or both sides. There was a significant reduction of the respiration of high-moisture wheat and kernels inoculated with Aspergillus repens, when irradiated at dosages greater than 11500 rep (total dosage at 1000000 v) and 19500 rep (total dosage at 600000 v), respectively, whether radiation was applied on 1 or both sides. (P.C.H.)

**10375** ON THE STERILIZATION OF THE CHICK EMBRYO BY X-RAY IRRADIATION OF THE EXTRA-EMBRYONIC GERMINAL CRESCENT. Régis Dubois (Collège de France, Paris). Arch. Anat. Microscop. Morphol. Exptl., 51: 85-94(Jan.-Mar. 1962).

Attempts were made to sterilize the chick embryo by local irradiation at various stages of development. By means of a Pb shield, the premordial germinal zone was selectively irradiated with 4000 to 12000 r in embryos at the 4- to 9-somite stage. Single doses of radiation failed to cause destruction of all germ cells and sterility was only 65 to 93% complete, based on the number of germ cells subsequently appearing in embryos compared with the number in control embryos. However, 100% sterility could be achieved if fractional doses were given several hours apart. For example, all germ cells could be destroyed if the germinal crescent was irradiated with 2750 r at the 6-somite stage followed by 5500 r at the 8-somite stage, or by 6875 r at 4 somites followed by 4125 at 7 somites. Similar fractional doses at later stages of development (9-12 somites) produced only 98 to 99% sterility. Irradiation and manipulation of embryos at early stages caused high mortality, about 95%. Irradiation caused the development of atypical giant cells in germinal tissue, which were incapable of mitosis. It was concluded that irradiation blocks mitosis without blocking cellular growth. Male germinal cells appeared to be more radiosensitive than female cells. (H.H.D.)

**10376** ACTION OF X RAYS ON BILIRUBIN AND BILIVERDIN IN A PROTEIN MEDIUM. G. Barac, M. L. Beaumariage, C. Cuvelier, and W. Notay (Université, Liège). Arch. Intern. Pharmacodyn., 131: 239-41(1961). (In French)

The nature of the complex between bile pigments and serum albumin was investigated by irradiating the pigments in the presence of proteins. Bilirubin and biliverdin were dissolved in canine plasma or in solutions of bovine serum albumin or human γ-globulin in pH 7.35 phosphate buffer. Two-ml volumes of the samples were irradiated with soft x rays (50 kv) at a rate of 236 r/sec to doses up to 300 kr. Based on percentage recovery of the pigments after irradiation, the protein showed a radioprotective effect, particularly at doses below 100 kr. In the presence of 4% albumin over 90% of bilirubin was recoverable after 100 kr, in contrast to less than 15% in the absence of protein. The action of albumin was not attributable to its sulfhydryl groups, since blocking the groups with Hg did not eliminate its radioprotective effect. γ-Globulin, which does not bind bilirubin, did not prevent its radiolysis. Biliverdin was equally protected by albumin. (H.H.D.)

**10377** DEVELOPMENT OF EXPERIMENTAL RADIATION PNEUMONITIS. F. L. Jennings and A. Arden (Univ. of Texas, Galveston). Arch. Pathol., 71: 437-46(Apr. 1961).

Histologic changes were studied in the lungs of rats irradiated with 3000 r to the thorax with shielding of the remainder of the body. In some animals the same total dose was given as 5 weekly doses of 600 r or in 2 doses spaced 50 days apart. Development of radiation pneumonitis in rats was characterized by an early inflammatory reaction with progressive organization of fibrin-rich edema fluid in alveolar septa. Later stages showed thickened alveolar septa containing large numbers of heavy reticulum fibers. Fractionation of radiation, either by multiple weekly doses or 2 large doses at a 7-week interval, did not appreciably alter the development of radiation pneumonitis. This suggests that previous exposure does not make the lung more radiosensitive but that the parenchymal changes are a function primarily of the total radiation dosage. Observations in the lung conformed with results in longevity studies showing that there is relatively rapid recovery from radiosensitivity induced by previous exposure. Rats exposed to massive thoracic radiation developed acute necrotizing esophagitis, resulting in extensive mortality. In contrast to the changes in man following thoracic radiation, the development of a hyaline membrane was not conspicuous in rats. Thus it is doubtful that organization of a hyaline membrane plays a significant part in the fibrous thickening of alveolar septa in the animals. (H.H.D.)

**10378** PROTECTION AGAINST LETHAL EFFECTS OF INTESTINAL RADIATION BY SURGICAL ISOLATION OF

THE IRRADIATED SEGMENT. J. Chandler Smith (Western Reserve Univ., Cleveland). Arch. Pathol., 71: 494-501 (May 1961).

A segment of small intestine of rats was exteriorized and irradiated with the rest of the body shielded. Irradiation of 50% of the ileum with 2000 r produced an acute intestinal syndrome with a mortality of 100% when the irradiated segment was left in continuity with the rest of the gut. When the irradiated segment was surgically isolated from the rest of the intestine by double ileostomy, the syndrome did not develop. Therefore, the harmful effect of segmental gut irradiation is dependent on the irradiated segment being in continuity with the rest of the intestine. This indicates that a radiotoxin of tissue origin is not important to the pathogenesis of the intestinal syndrome, and that the physical denudation of the ileal mucosa is not sufficient by itself to cause the syndrome. It is suggested that the outpouring of fluid may be due to atony of the injured segment or to some property of the intestinal content acting on the denuded surface. (H.H.D.)

**10379** THE "BROWN SPOT" CHARACTER IN DROSOPHILA MELANOGASTER AND THEIR RESPONSE TO X RAYS. A. Di Pasquale (Università, Milan). Atti Assoc. Genet. Ital., 5: 117-26(1960). (In Italian)

Some preliminary observations concerning a new character of D. melanogaster consisting in brown spots appearing on the abdomen of the females, some days after birth are reported. The brown spots are restricted to the hypodermal cells of the pleurae. Size and number of spots per individual are variable. This character appears in all isogenic chromosomal combination involving the second chromosome, derived from the wild stock Aspra 52, which fails to show spots, and has a manifestation of tumors (60%). The spots appear some generations after the establishment of the isogenicity. Treatment of larvae and pupae with x rays fails to induce the spots in the males; but increases the size of the spots. A possible cytoplasmic effect is discussed, as well as the connection between brown spots and tumors. (auth)

**10380** GENETIC DAMAGE IN SEEDS OF MAIZE TREATED WITH X RAYS AND WITH NEUTRONS UNDER DIFFERENT PHYSIOLOGICAL CONDITIONS. A. Bianchi (Università, Milan). Atti Assoc. Genet. Ital., 5: 137-48 (1960). (In English)

Curtis et al., have demonstrated that in barley the "physiological" effects of x ray and neutron treatments on dormant seeds may be significantly altered by varying the moisture content of the seeds or their storage after treatment. Somewhat similar treatments were repeated on seeds of heterozygous maize for alleles of the $yg_2$ locus. Somatic sectors, representing loss or inactivation of the dominant allele, provide a criterion of genetic change in the short arm of chromosome 9. The scoring of the 5th leaf of the seedlings sprouted from the irradiated seeds for yellow-green streaks in green background were recorded. The water content of the treated seeds were about 6 to 13 and 26 to 32% respectively. The planting times were from few minutes after treatment up to weeks. Under such experimental conditions no great differences were observed, although they are, by and large, in the sense of reported results. (auth)

**10381** EFFECT OF X RAY TREATMENT ON WHEAT SPECIES WITH DIFFERENT PLOIDY. D. L. Palenzona (Università, Pavia, Italy). Atti Assoc. Genet. Ital., 5: 161-74(1960). (In Italian)

Research carried out by Schwartz, Moutschen and others, on maize, barley and hexaploid wheat, has made evident the fact that some traits, after a point of maximum sensitivity to radiation (at different doses, according to the trait and the plant species studied) show a diminution of radiosensitivity which has been called "reversal phenomenon." Schwartz has postulated that the point of maximum radiosensitivity at low doses can be attributed to chromosome breakage that induces death by aneuploidy, and the diminution of radiosensitivity at high doses is caused by an inhibition of mitosis. With the goal of studying the behavior of species of different degrees of ploidy belonging to the same genus, three species of wheat, T. monococcum (diploid), T. durum (tetraploid), T. vulgare (hexaploid), were treated with x rays up to 240,000 r. The degree of humidity of the seeds at the time of radiation was 5% and 13%. It was possible to identify on the basis of the data obtained, the influence of the degree of ploidy, the degree of humidity, the trait considered on radiosensitivity in general, and on the manifestation of the "reversal phenomenon." The results obtained show that the effects of high doses of ionizing radiations have a fairly complex determination. Examination of the behavior of certain characters such as the dry weight of the seedlings, which gives an indication of the metabolic activity of the irradiated material, suggest that the "reversal phenomenon" might also include an inhibition of the autocatalytic activity (reduplication) of the hereditary material while the heterocatalytic activity (gene function) remain undamaged. At even higher doses this latter activity would also be inhibited and radiation death occurs. For greater clarity of the mechanisms of the effects of high doses of ionizing radiations, other experiments are planned which forsee the use of chemical and physical modification of radiosensitivity. (auth)

**10382** GENETIC EXPERIMENTS IN THE BOREK-RYAN EFFECT. E. Calef, G. Giardina, and G. Modiano (Università, Pavia, Italy). Atti Assoc. Genet. Ital., 5: 247-53(1960). (In Italian)

Experiments on the mechanism of the effect discovered by Borek and Ryan, dealing on the phenomenon of lysogenic induction by a uv-treated male of E. coli K 12, when crossed to a non-irradiated F-, are reported. The results seem to show a correlation between the entrance of a given portion of the chromosome and the beginning of the induction. Results are also reported on the possibility of getting a mutagenic effect through the event of conjugation. (auth)

**10383** EFFECTS OF X RAYS ON GUINEA PIG CELLS CULTIVATED IN VITRO. G. Marin and G. Colombo (Università, Padova, Padua). Atti Assoc. Genet. Ital., 6: 125-38(1961). (In Italian)

Some effects of x rays were studied on a cell strain cultivated in vitro, derived from guinea-pig kidney. Survival values of the strain and of two clonal derivatives were estimated by counting the number of macroscopic colonies developed from single cells irradiated with doses ranging from 50 to 750 r. Moreover a quantitative evaluation of colony growth and polinucleated cell appearance, during four division cycles following irradiation of single cells with several doses (76, 150, 450, and 600 r), was carried out on cytological preparations. It is concluded that the more prominent effect which parallels reproductive death is an inhibition of cytodieresis due to some kind of genetic damage, while nuclear division is less affected. An hypothesis about the kind of processes which may presumably be involved is proposed. (auth)

**10384** PRELIMINARY NOTE ON THE VARIATION OF SOME FITNESS FACTORS IN PERIODICALLY IRRADIATED DROSOPHILA MELANOGASTER POPULATION.

M. Carfagna, A. Solima, and A. De Capoa (Università, Naples). Atti Assoc. Genet. Ital., 6: 277-84(1961). (In Italian)

Two populations of Drosophila melanogaster were irradiated periodically with small doses of x rays (100 r and 500 r). Two other populations were cultured as controls at the same time. All the populations were held at 19° ± 1°C in a constant temperature room. On the 150th and 225th day the hatchability and the fertility were assayed on samples of eggs obtained from individuals, not directly irradiated, taken from each population. The relative data indicate a percentage diminution of these two fitness factors in the populations irradiated with 500 r and to a smaller extent in those irradiated with 100 r. The diminution in fitness is interpreted as being due to the accumulation of lethal genes induced by the irradiation. At intervals of 25 days the numerical levels were determined and this was carried out 17 times. The totals obtained in the 17 counts are significantly higher (with the $\chi^2$ test) in the populations irradiated with 500 r than in the controls and in those irradiated with 100 r. However, the test for heterogeneity was positive. If these observations are confirmed, they could be interpreted as being due to a greater adaptability in the irradiated populations in a selective environment. (auth)

**10385** MUTATIONS INDUCED WITH X RAYS IN ANOPHELES MACULIPENNIS. G. Frizzi (Università, Cagliari, Italy) and M. S. Jolly. Atti Assoc. Genet. Ital., 6: 285-90(1961). (In Italian)

Adult males of A. mac. atroparvus were treated with x ray doses of 2000, 2500, 4000, 5000, and 6000 r. The highest rate of chromosomal aberrations were obtained with 3500 r; 6000 r gave complete sterility. The most frequent types of mutations were inversions, both paracentric and pericentric; few deficiencies and translocations were found. The embryonic and larval mortality increases with the dose. Possible implications of applied radiogenetics of Anopheles are discussed. (auth)

**10386** THE EMBRYONIC TRANSPLANT AS RESEARCH MEDIUM IN THE EMBRYO-ENDO SPERM IN IRRADIATED SEEDS. P. Meletti and F. D'Amato (Università, Cagliari, Italy and Università, Pisa, Italy). Atti Assoc. Genet. Ital., 6: 323-32(1961). (In Italian)

Seeds of Bonus barley and Albimonte wheat, irradiated with high doses of x rays, thermal neutrons, and gamma rays, were used in embryo transplantation experiments in both directions: (1) irradiated embryo on unirradiated endosperm, EM(i)/EN(n), and (2) unirradiated embryo on irradiated endosperm, EM(n)/EN(i). Intact seeds as well as homotransplants (unirradiated embryo on unirradiated endosperm) served as controls. In a first series of experiments with barley (x-ray doses of 50, 100, 200, and 400 Kr), the most common transplantation technique was used, which leaves some residual endosperm attached to the embryo to be transplanted (technique A). No clear effect of the irradiated endosperm on the unirradiated embryo was observed, neither on seedling growth nor on plant survival in the field. On the contrary, in a total of 2400 irradiated embryos (600 for each x-ray dose) grafted on unirradiated endosperm, 33 mature plants were obtained (no survival from the control seeds irradiated with the same x-ray doses). A genetic test in the following generation did not reveal any seedling mutation neither in the EM(i)/EN(n), nor in the EM(n)/EN(i) plants. In another series of experiments on barley with a more refined technique, which allowed the transplantation of completely endosperm-free embryos (technique B), it was found that: a) x-irradiated endosperm tends to reduce both shoot and root growth of EM(n)/EN(i) seedlings; b) with thermal-neutron-irradiated endosperm, growth depression is observed only in the root system of the embryo grafted on it. Using technique B in Albimonte wheat, it was also shown that heavily gamma-irradiated endosperm depresses growth in both the root and shoot systems of the embryo transplanted on it (doses of 250, 500, and 1000 Kr were used). A strong reduction in field survival has also occurred for unirradiated embryos transplanted on endosperms irradiated with 1000 Kr of gamma rays. From the experience gained so far, the authors conclude that the embryo transplantation technique, if refined conveniently, may prove useful in studying embryos-endosperm relations in irradiated seeds. (auth)

**10387** POLYGENIC MUTABILITY INDUCED BY X RAYS IN NICOTIANA TABACUM. G. Wittmer (Istituto Scientifico Sperimentale per i Tabacchi, Rome). Atti Assoc. Genet. Ital., 6: 333-42(1961). (In Italian)

Variability of flower characters in $R_2$ progeny derived from seeds of tobacco variety Virginia bright strain T.19, treated with different doses of x rays, was studied; observations were made on progenies obtained by controlled selfing. The method of analysis used was the following one: (1) analysis of variance within the treatment groups in order to esteem the contribution to the phenotypic variability, referable to genetic differences between lines and to environment; (2) test of heterogenity of variances; (3) comparison between treatment and control variances; (4) co-variance analysis for few characters. The most significative results are as follows: for two characters (breadth of throat; length of corolla) the variability of the treated lines is significantly higher compared with variability of the control lines; in the treated series a positive correlation is found between both characters, while in the control series the two characters are independent. The observed increase of variability is briefly discussed from the point of view of a possible role of induced increase of recombination frequency and of induced polygenic mutability. (auth)

**10388** EFFECTS OF RADIATION AND CHEMICAL MUTAGENIC AGENTS ON THE GROWTH AND SURVIVAL IN ITALIAN VARIETIES OF DURUM WHEAT. S. Avanzi (C.N.E.N., Rome). Atti Assoc. Genet. Ital., 6: 353-64 (1961). (In Italian)

A study was made of the comparative effects of radiations (x rays, thermal neutrons, and fast neutrons) and of three chemical substances (β-propiolactone, ethylene chloride, and diethyl sulfate) on seedling growth and plant survival in the field in the durum wheat varieties Aziziah, Cappelli, and Russello. In agreement with previous investigations on barley (Ehrenberg and Wettstein, 1955; Avanzi, 1960), it was found that both thermal and fast neutrons are able to inhibit root growth more strongly than shoot growth, while an almost identical degree of growth inhibition is observed in the two organs with x rays and chemicals; maximum depressing effect is observed in the thermal neutron series. As to field survival, clear differences between thermal and fast neutrons on one side and x rays and chemicals on the other are seen, if the mature plant-/3-leaf seedlings ratio is taken into account. Among the three varieties investigated, Aziziah was found as the most radiosensitive one; no statistical difference in radiation sensitivity between Cappelli and Russello was detected. Response to chemicals of Cappelli and Aziziah varies according to type of treatment and effect studied. With ethylene chloride, Cappelli is more sensible than Aziziah as to seedling growth and more resistant as to field survival. With β-propiolactone and diethyl sulfate, Cappelli is more affected than

Aziziah in both field survival (all treatments) and seedling growth (some treatments). (auth)

**10389** CHROMOSOMIC MUTANTS INDUCED BY IONIZING RADIATIONS IN "CAPPELLI" DURUM WHEAT. A. Bozzini (C.N.E.N., Rome). Atti Assoc. Genet. Ital., 6: 365-70(1961). (In Italian)

Among 13 $R_3$ morphological or chlorophyll mutants of durum wheat "Cappelli," 3 progenies carrying a reciprocal translocation were found. Such chromosomic aberrations do not increase sterility. Translocation homozygous lines are now going to be obtained. Cytological investigations of abnormal $R_4$ plants showed a transmissible dicentric chromosome (2n = 26 + 1 dic). Preliminary data concerning the mitotic behavior of the dicentric and fertility of the individuals so far cytologically investigated are reported. (auth)

**10390** MORPHOLOGICAL MUTATIONS INDUCED BY RADIATIONS IN "CAPPELLI" DURUM WHEAT. G. T. Scarascia (C.N.E.N., Rome), F. D'Amato, and A. Bozzini. Atti Assoc. Genet. Ital., 6: 371-80(1961). (In Italian)

The authors report briefly on their collection of radiation-induced morphological mutations in the durum wheat variety "Cappelli." 52 mutations for single morphological characters are tabulated; they appeared as single mutations per $R_1$ seed (33 cases) or as two (5 cases) and three (3 cases) contemporary independent mutations per $R_1$ seed. The mutations involved changes in the following characteristics: mode of tillering, leaf shape and size, wax cover, culm anatomy, and morphology of spike, glume, and caryopsis. Of special interest are mutations for solid stem, fused-margin leaf, and defective endosperm. More than $^2/_3$ of the mutations tabulated appeared in thermal neutron experiments. A 3:1 segregation ratio, with the mutant character appearing as recessive, was observed for the following mutations: waxless, short straw, and compact spike. 17 mutations are reported showing a complex phenotype (two or more changed characters constantly associated); they are regarded as the result of a single mutational step. Especially interesting is the monogenic recessive mutation "elongated rachilla, increased waxiness, and slender culm," characterized by an increased number of nodes and strong elongation of the internodes in the rachilla, leading to a pseudo-branched spike. This mutation is very similar to the one obtained by Barabas (19-59) in his x-ray experiments on Triticum carthlicum. (auth)

**10391** QUANTITATIVE VARIABILITY AFTER IRRADIATION OF TOMATO SEEDS. D. L. Palenzona (Università, Pavia, Italy). Atti Assoc. Genet. Ital., 6: 381-94(1961). (In Italian)

In order to compare mutability by x rays with spontaneous mutability, dormant seeds of an autodiploid strain of Lycopersicon pimpinellifolium were irradiated with 4000 r. According to Lindstrom (1941) it was assumed that in this strain no genetic variability was present; moreover the experiment was planned so that the effect of various types of selection (intrasomatic, gametic, zygotic) could be estimated. A great amount of variability was found in plants from nonirradiated seeds. This result suggests that the assumption of complete homozygosity of autodiploid strains must be reconsidered. In our experiment, however, such results may be a consequence of aging of the seeds. Intrasomatic, gametic, and zygotic selection effects were found both in plants from irradiated and non-irradiated seeds, but their consequences are more striking in plants from irradiated seeds. The variability between plants within lines from irradiated seeds does not differ from that of lines from nonirradiated seeds, but this discrepance from expectation can be explained also by the different effect of gametic and zygotic selection on the two groups of plants. (auth)

**10392** THE EFFECT OF X-RAY TREATMENT COMBINED WITH AIR, NITROGEN, OR OXYGEN IN DROSOPHILA MELANOGASTER STUDIED ON SEX-LINKED RECESSIVE LETHALS. L. V. Pozzi, S. Giavelli, G. P. Sironi, and E. Gallucci (Università, Milan). Atti Assoc. Genet. Ital., 7: 170-9(1962). (In Italian)

Germ cells of spermatogenesis of D. melanogaster were treated with 600 r of x rays. The sensitivity spectrum for recessive sex-linked lethals, obtained by crossing the treated males for 12 successive days, shows a maximum in days 5 to 7, corresponding to treated spermatids; this confirms data already known. Anoxia lowers the sensitivity throughout the whole spectrum, particularly for spermatids; $O_2$ treatment increases x-ray damage, although not uniformly in the different stages of spermatogenesis: the less sensitive cells under these circumstances are spermatids and spermatogonia. (auth)

**10393** INTERACTION OF X AND ULTRAVIOLET RADIATION IN PRODUCTION OF RECESSIVE LETHALS IN DROSOPHILA MELANOGASTER. B. Nicoletti and G. Olivieri (Università, Rome). Atti Assoc. Genet. Ital., 7: 180-90(1962). (In Italian)

The possibility that uv rays given to different biological systems before or after x rays could modify genetic or cytological effects is reviewed and discussed. Kaufmann and Hollaender's conclusions about the recovering effect of uv rays on chromosomal damage induced in Drosophila sperms by a pre-treatment of x rays are discussed and analyzed taking into account some general considerations. Preliminary results of similar experiments on the frequency of sex-linked recessive lethals induced after single and combined x + uv treatments in Drosophila sperms are reported. All our experiments indicate no effect of the uv treatment (at the given wave lengths and doses) in lowering the frequency of the x-ray-induced recessive lethals. On the contrary, there are some indications for a synergistic action between the two radiations. These results not in agreement with the generally accepted theory that uv rays do recover x-ray-induced chromosomal damages, could be explained with the well established correlation between chromosomal rejoined breaks and genic mutations. (auth)

**10394** INFLUENCE OF TEMPERATURE ON THE FREQUENCY OF SOMATIC MUTATIONS INDUCED BY X RAYS IN MAIZE SEEDLINGS. A. Bianchi and M. Contin (Università, Milan). Atti Assoc. Genet. Ital., 7: 240-9 (1962). (In Italian)

The frequency of yellow-green sectors on the green background of heterozygous maize seedlings $Yg_2/yg_2$ ($yg_2$ = yellow-green-2 on short arm of chromosome 9) was used as a criterion of measuring somatic mutation rate induced by x irradiation (3 to 8 kr) on seeds possessing water content of 4 (dry seeds) or 11% (normal seeds) at different temperatures. With dry seeds the mutation rate is the same at −70 and 20°C, but drops significantly and linearly passing from 20 to 35, 50, and 65°C. Such decrease is great for the third leaf, moderate for leaf four, and slight for leaf five. In seedlings sprouted from seed irradiated with 11% of moisture content, on the contrary, the sensitivity plateau of the dry seeds, between −70 and 20°C is missing, since the mutation rate at 20°C is already clearly lowered as compared with that of −70. (auth)

**10395** X RAY INDUCED MUTATIONS IN VICIA SATIVA L. L. Zannone (Istituto Nazionale di Genetica per la Cere-

alicoltura, Rome). Atti Assoc. Genet. Ital., 7: 266-74 (1962). (In English)

Two lots of V. sativa L. seeds with water content of about 8% were irradiated with different doses of x rays, and the $X_2$ seedlings were evaluated for induced mutations. The first lot, including samples of 100 seeds treated with the following doses: 0, 5, 10, 15, 20, and 25 kr, was raised in pots; the other one, including samples of about 1500 to 1600 seeds for each of the doses 0, 10, 15, and 25 kr, was sowed in the field. 50% survival of the $X_1$ plants in the two lots corresponded to a treatment dosage of about 15 kr. From each dose 40 $X_1$ plants from the field were isolated in cloth bags to insure self-fertilization. Mutation data presented here are collected from the plants isolated in the field and from all plants raised in pots. Main branches, secondary branches, and pods were separately harvested from single plants. The data obtained demonstrated also in this species the chimaeric type of mutation. In fact 26 out of 29 mutations observed in $X_2$ progenies derived from only one branch of the plant. The highest rate of induced mutation, expressed as percentage of $X_1$ plants and of $X_2$ seedlings, was obtained with 15 kr. This result is in agreement with those on somatic damage previously obtained. Types of mutation observed at seedling stage were chiefly chlorophyll mutants (68.6%). Morphological (11.4%), dwarf (17.1%), and lethal (physiological stress, 2.9%) mutants were observed too. Chlorophyll mutants were classified according to a scale running from an apparent lack of chlorophyll in presence of anthocyanin to a lack of anthocyanin in presence of chlorophyll. However, a more exact classification of the different types calls for further study. (auth)

**10396** THE EFFECT OF RADIATION IONIZATION DENSITY (LET) UPON THE REPRODUCTIVE CAPACITY OF MAMMALIAN TUMOUR CELLS IRRADIATED AND ASSAYED IN VIVO. Roger J. Berry and J. Robert Andrews (National Cancer Inst., Bethesda, Md.). Brit. J. Radiol., 36: 49-55(Jan. 1963).

The response of mammalian tumor cells to ionizing radiation was studied in vivo using the transplantability of leukemic ascites cells as a measure of cell reproductive capacity. Dose-response curves are presented under both oxygenated and anoxic conditions for x rays, $Co^{60}$ $\gamma$, fission-spectrum fast neutrons, 14-Mev monoenergetic neutrons, and for irradiation with both the plateau and Bragg-peak regions of beams of 340-Mev protons and 380-Mev $\alpha$ particles. The significance of changes with LET in $D_0$ (37% dose) slope and extrapolation number of the dose-response curves are discussed and additional evidence is presented of correlation between the ability of cells to show recovery with fractionated irradiation and dose-response extrapolation numbers greater than unity. Considerations for the use of high LET (densely-ionizing) radiations in radiotherapy of human cancer are discussed. (P.C.H.)

**10397** EFFECT OF X RAYS ON THE ACCUMULATION OF CATALASE IN CONIDIA OF ASPERGILLUS NIGER. Wen-Hwa Tai. Bull. Inst. Chem. Acad. Sinica, No. 6, 71-8 (July 1962).

Investigations were made on the effect of x radiation of low dose rate on the accumulation of catalase in conidia of Aspergillus niger. The activity of catalase was determined by measuring the oxygen evolved from hydrogen peroxide in a conventional Warburg manometric apparatus at 30°C. X irradiation for 20 min (corresponding to about 5400 rads) increased the catalase activity to a maximum. At this point the activity was found to be 112 $\mu$l $O_2$/mg conidia. It was concluded that x radiation, when applied at low dose rate, is feasible for the increase of catalase activity of conidia of Aspergillus niger, whereas ultraviolet light consisting chiefly of wave-length 360 m$\mu$, is responsible for the inactivation of the enzyme. (P.C.H.)

**10398** A CYTOGENETIC STUDY OF THE X-RAY INDUCED CAULIFLOWER-HEAD AND SINGLE-LEAF MUTATION IN MEDICAGO SATIVA L. Beatrice E. Murray and Iris L. Craig (Canada Department of Agriculture, Ottawa). Can. J. Genet. Cytol., 4: 379-85(Dec. 1962).

Data obtained from $X_2$, $X_3$, and $X_4$ segregation ratios demonstrate that two closely associated characteristics, cauliflower-head and single-leaf, are determined by a single recessive gene inherited tetrasomically. Chromosome counts revealed a trisomic tetraploid with 31 chromosomes, the normal complement (2n = 32), and mutants showing an unstable condition. It is suggested that the chromosomal variation could have been induced by x radiation or it may have been transmitted from one of the parents. The trisomic genotype does not affect the phenotype of the mutant. The results are discussed in connection with pollen x irradiation and the polyploid nature of M. sativa L. (2n = 32). (P.C.H.)

**10399** A MORPHOLOGICAL STUDY OF THE X-RAY INDUCED CAULIFLOWER-HEAD AND SINGLE-LEAF MUTATION IN MEDICAGO SATIVA L. I. L. Bayly and Iris L. Craig (Carleton Univ., Ottawa and Canada Department of Agriculture, Ottawa). Can. J. Genet. Cytol., 4: 386-93(Dec. 1962).

The morphology of a spontaneous and an x-ray induced cauliflower-head and single-leaf mutation was compared with normal alfalfa. Chromosome numbers were 32 in the normal and the spontaneous mutation, 31 in some, but not all, of the x-ray induced lines. The cauliflower mutant was unrelated to the trisomic tetraploid condition of the B45 line. Flower development in x-ray-induced cauliflower-head was restricted to profusely branched floral axes that produced only meristem primordia, and under treatment with gibberellic acid, rudimentary pistils, but no stamens, petals, or sepals. Flower development in the spontaneous mutation showed sparingly branched floral axes, which produced rudimentary pistils and linear bracts homologous with sepal-petal primordia. With gibberellic acid treatment, pistil development approached normal, but no stamens, petals, or sepals were produced. Leaf development, which is trifoliate in normal alfalfa, was unifoliate in both mutants. The unifoliate leaf appeared to result from suppression of lateral leaflet primordia. The results suggest that the x-ray induced mutation, although similar, is more extreme and rudimentary, in tissue differentiation, than the spontaneous mutation. (P.C.H.)

**10400** THE EFFECT OF MATERNAL AGE AND RADIATION ON THE RATE OF NON-DISJUNCTION IN DROSOPHILA MELANOGASTER. Irene A. Uchida (Univ. of Manitoba, Winnipeg and Children's Hospital, Winnipeg, Manitoba). Can. J. Genet. Cytol., 4: 402-8(Dec. 1962).

The effects of maternal age and radiation on the rate of non-disjunction of X chromosomes of Drosophila melanogaster aged from one to 29 days before mating was studied. In the absence of radiation there was no detectable effect of maternal age on the frequency of XO and XXY progeny in Drosophila melanogaster. With irradiation, however, there was, in addition to an overall increase, a significant effect of maternal age. Females who were older at the time of irradiation produced more exceptional progeny, in agreement with previous results. (P.C.H.)

**10401** MUTAGENIC EFFECT OF $C^{14}$ AND $H^3$ LABELLED DNA PRECURSORS INJECTED INTO DROSOPH-

ILA MELANOGASTER MALES. Oeistein Stroemnaes (Univ. of Oslo). Can. J. Genet. Cytol., 4: 440-6(Dec. 1962).

Four groups of Drosophila melanogaster males were injected with $C^{14}$ and $H^3$ labeled DNA precursors. In one group the males were injected as larvae. In three other groups and in a control group all males were injected 6 to 24 hours after emergence from the pupal case. In the control group a nonlabeled DNA precursor was used. Dominant lethals measured as the frequency of non-hatched eggs seemed not to be induced by the amount of radioactivity used. There was, however, a significant increase in the frequency of sex-linked recessive lethals. There are indications that the highest frequency of lethals are induced in the sperm that are available for insemination 12 to 13 days after injection. (P.C.H.)

**10402** SPERMATOCYTE DIVISION IN TUPLIDAE. III. REARRANGEMENT OF CHROMOSOMES IN TRANSLOCATED HETEROZYGOTES OF TIPULA OLERACEA. Hans Bauer, Roland Dietz, and Christa Roebbelen (Max-Planck-Institut für Meeresbiologie, Wilhelmshaven, Ger.). Chromosoma, 12: 116-89(June 20, 1961). (In German)

Mature sperms were irradiated with 60-kv x rays at a dose of 3500 r. The resulting chromosomal rearrangements were studied in $F_2$ males obtained by mating $F_1$ sons of irradiated fathers with normal females. By this method, rearrangements including the X chromosome were not obtainable. More than half of the $F_2$ families contained rearrangements. Predominant among them were reciprocal translocations between 2 of the 3 autosomes, followed in frequency by translocations between all 3 autosomes. Reciprocal translocations between an autosome and the small Y chromosome were present in about 5% of $F_2$. During the first maturation division the kinetochores of the 2 chromatids of each chromosome (whether univalent or member of a bivalent or trivalent) can be oriented in 1 of 2 ways: they may be directed to the same pole (syntelic), or they may be oriented to different poles (amphitelic). When kinetochores are syntelic a chromosome lies with its axis parallel to that of the spindle and the data suggest that from early prometaphase until late anaphase it is subjected to forces which act in the direction of that pole towards which the kinetochores are oriented. Nearly all of the possible patterns of orientation of bivalents and multivalents were found, but the frequencies with which specific patterns occurred were not those predicted on the basis of chance alone. (H.H.D.)

**10403** STUDIES ON THE DISTRIBUTION OF BREAKAGE SITES OF NATURAL AND RADIATION-INDUCED CHROMOSOME DISLOCATIONS IN DROSOPHILA SUBOBSCURA COLL. E. Kunze-Muehl (Universität, Vienna). Chromosoma, 12: 286-309(July 12, 1961). (In German)

Cytologic analysis of radioinduced dislocations was studied in salivary gland chromosomes of the $F_1$ larvae produced by mating irradiated male flies with normal females. The males, 10-day-old individuals of the Küsnacht strain, were irradiated with 5000 r. Examination of the salivary glands of 646 $F_1$ larvae revealed a total of 74 translocations and 30 inversions in 92 larvae. On the basis of previous studies, dislocations corresponded to 234 breakage points. The percentage of dislocations in the sperm ($14.24 \pm 1.37\%$) was lower than that obtained in previous experiments on other Drosophila species, at the same radiation dose. The distribution of the 234 radioinduced and 152 natural breakages was considered on a statistical basis. The radioinduced breaks showed a random distribution in the chromosomes and also within chromosomes on the basis of large segments. On the basis of small segments, however, 3 autosomes showed a significant deviation from random distribution. This applies especially to the frequent occurrence of equidistant breaks at fixed sites. On the other hand, the distribution of naturally occurring breaks was very nonuniform. In particular, the proximal segments of all autosomes showed fewer breakage points than other segments. A comparison between short segments of autosomes showed a significant deviation from random distribution, which appeared to be due to the coincidental accumulation of natural breaks. A marked coincidence of radioinduced and naturally occurring breaks was suspected, but could not be proved. (H.H.D.)

**10404** THE KINETOCHORE OF THE HEMIPTERA. Sally Hughes-Schrader and Franz Schrader (Duke Univ., Durham, N. C.). Chromosoma, 12: 327-50(July 27, 1961). (In English)

To induce chromosome breakage, adult males and nymphs of Euschistus servus, E. tristigmus, and Solubea pugnax were irradiated with 100 to 750 r doses of x rays. The diffuse nature of the kinetochore was demonstrated by the ability of chromosome fragments to perpetuate themselves mitotically through many cell generations of spermatogonia. Free fragments, when not immobilized by the effects of radiation, are also capable of meiotic mitosis. A holokinetic, rather than a telomeric, nature was thus demonstrated for the meiotic restriction of kinetochore activity to chromosome ends, normal for Heteroptera and certain other Hemiptera. Simple fragmentation as a factor in the evolution of compound sex chromosomes was supported by the observation that fragments of the X chromosome coorient with the Y in a typical touch-and-go pairing. (H.H.D.)

**10405** PROTECTION BY CYSTEINE OF A PHOSPHATASE EXPOSED TO THE ACTION OF ULTRAVIOLET RADIATION. Bernard Magnan de Bornier and Nicole Bensaid (Faculte de Medecine, Montpellier, [France]). Compt. Rend., 255: 2201-3(Oct. 22, 1962). (In French)

Cysteine, which is an inhibitor of phosphatases, exercises a protective action on this enzyme when it is exposed in its presence to the action of ultraviolet radiations. As a result of these two antagonistic effects, there exists an optimum cysteine concentration for which the protective effect with respect to ultraviolet radiation is a maximum. (tr-auth)

**10406** DIFFERENCES IN THE APPEARANCE OF LYMPHOID TUMORS IN SPONTANEOUSLY RESISTANT MICE AFTER X IRRADIATION WITH OR WITHOUT ASSOCIATION OF A HOMOLOGOUS LEUKEMIC EXTRACT. M. R. Rivière, I. Chouroulinkov, C. Marty, and M. Guérin (Institut de Recherches Scientifique sur le Cancer, Villejuif, France). Compt. Rend. Soc. Biol., 156: 1035-8(1962). (In French)

Whole-body x irradiation at 300 r of mice of the XLII strain at various ages does not provoke the development of lymphomatoses. On the contrary, the injection of a homologous leukemic extract after irradiation causes lymphoid tumors in refractory animals. The young mice are more sensitive than the adults. These results confirm the important role of the mouse lineage in studies of this type. The mechanism of the action of the leukemic extract associated with irradiation still remains to be explained. (tr-auth)

**10407** ORGAN CULTURE AS A TECHNIQUE FOR CAUSAL EMBRYOLOGY AND ITS APPLICATION IN RADIOBIOLOGY. Elio Borghese (Comitato Nazionale per l'Energia Nucleare, Frascati, Italy). Embryologia (Nagoya), 6: 159-68(Nov. 1961). (RT/BIO(62)51). (In German)

The classical methods of experimental embryology in amphibia are compared with the more recently introduced

technique of culture in vitro of embryonic organs of warm-blooded animals. Some isolation and recombination experiments carried out by means of organ culture are described. It is shown, by examples taken from research in progress, how this technique is applicable radiobiological experiments. (auth)

**10408** EFFECTS OF RADIATION ON CELL AND NUCLEAR GROWTH IN PARAMECIUM AURELIA. R. F. Kimball and Lore Vogt-Koehne (Oak Ridge National Lab., Tenn. and Karolinski Inst., Stockholm). Exptl. Cell Res., 28: 228-38(Nov. 1962). (In English)

Specimens of Paramecium aurelia, syngen 4, stock 51 were irradiated with 66 kr of x rays or 485 to 970 ergs/mm$^2$ of 2537 Å ultraviolet 1 hr after division, and the growth of various cellular components was followed by microspectrophotometry, microinterferometry, and autoradiography. The rate of growth in total dry weight of the individual cell was immediately decreased and recovered later in the interdivision interval. Completion of the synthesis of macronuclear DNA, RNA, and protein was also delayed either by delay in onset of the syntheses, by decrease in the rate of the syntheses, or perhaps both. Division was delayed sufficiently by the doses used so that by the first division after irradiation the paramecia had essentially the same total dry weight and same size of macronuclei as the dividing controls. Duplication of the micronucleus was delayed by about 2 hr by 66 kr of x rays, and the postduplication interphase was decreased or eliminated. Food vacuole formation was almost completely inhibited immediately after x irradiation and the inhibition of increase in total dry weight was directly attributable to this circumstance. The effects of limited food and radiation were not identical in all respects. The control data confirm previous studies on growth of Paramecium and showed that the rate of food vacuole formation increases continuously during the interdivision interval. (P.C.H.)

**10409** THE EFFECT OF X-RADIATION ON FUMARASE ACTIVITY DURING DIFFERENT STAGES OF CELL DIVISION IN TETRAHYMENA PYRIFORMIS GL. W. D. Sullivan and Rita L. Snyder (Boston Coll., Mass.). Exptl. Cell Res., 28: 239-47(Nov. 1962). (In English)

Tetrahymena pyriformis GL was grown in a 2% solution of proteose peptone. The fumarase activity was tested at different stages of cell division in irradiated and non-irradiated cultures. There was a significant ($P < 0.05$) difference in fumarase activity in all cases between the irradiated and non-irradiated determinations. A comparison of the enzymatic activity in the controls and experiments of each stage with the activity of the stages immediately preceding and following showed a significant ($P < 0.05$) difference in all cases with the exception of the step from stage III to stage V in the controls. Ionizing radiation was found to inhibit fumarase activity. A high rate of enzyme activity found in the interphase stage of cell division is thought to be the result of an attempt of the organisms to replenish the energy needed to carry on the processes of cell division. An enlargement of the cells following exposure to ionizing radiation was noted. (P.C.H.)

**10410** PHOTORESTORATION OF FRAGMENTS OF IRRADIATED AMOEBA. Yvette Škreb and Ljerka Bevilacqua (Faculty of Medicine, Zagreb). Exptl. Cell Res., 28: 430-2(Nov. 1962). (In French)

Studies were made on the restoration of fragments of amoeba following 1200 ergs/mm$^2$ ultraviolet radiation. An excellent restoration of the total quantity of RNA was found. The numbers corresponding to the nucleated fragments illuminated were even superior to those corresponding to the controls. The ratio between illuminated and irradiated fragments was 1.43 and among the anucleated was 1.25. The results confirmed the fact that photorestoration exerts some actual beneficial effects that manifest themselves with different intensity following the cellular constituent considered. It was concluded that the chromophore exists in the cytoplasm of the amoeba since the consequences of the photorestoration manifests itself almost in the same manner in the two types of fragments that are concerned with the evolution of RNA. (P.C.H.)

**10411** CHANGE IN THE METAPHASE/PROPHASE RATIO AS AN INDICATOR OF DAMAGE BY SMALL DOSES OF X-RAYS. Z. Karpfel and V. Kolář (Biophysical Inst., Czechoslovak Academy of Sciences, Brno and Cancer Inst., Brno). Exptl. Cell Res., 28: 433-5(Nov. 1962). (In English)

Whether the particular type of c' mitosis found in irradiated mice is also found in human beings was investigated. In mice, the time course of the change in the M/P ratio depended on the level of the dose applied. Similarly, the numerical value of the change was also dependent on the dose. After a dose of 500 r the abnormal finding lasted more than one week, which means that it was also observed in the stage of intensive regeneration. Fifteen hours after radiotherapy of persons, there also occurred an increase in the number of metaphases of all bone marrow specimens aspirated by sternal puncture. The change in the ratio of the first two stages of mitosis appears to be a sensitive indicator of bone marrow damage as a result of exposure to low doses of radiation. (P.C.H.)

**10412** ON THE ROLE OF THE THYMUS IN RECOVERY OF IMMUNOLOGICAL REACTIVITY FOLLOWING X-IRRADIATION. A. Globerson, L. Fiore-Donati, and M. Feldman (Weizmann Inst. of Science, Rehovoth, Israel). Exptl. Cell Res., 28: 455-7(Nov. 1962). (In English)

Studies were made on the role of the thymus in the spontaneous recovery of immune reactivity in mice following exposure to x irradiation. The immune reactivity of mice treated with urethan following thymectomy was also tested. Urethan-treated mice showed a normal rejection of tumor homografts; only 1 out of 9 tumors showed palpable growth, which was then rejected on the 16th day. In mice thymectomized and then treated with urethan, 4 of 13 grafts gave palpable takes, but all were rejected between the 15th and 22nd day. X irradiated recipients showed a higher percentage of palpable growth (5/8), which was rejected between the 17th and 26th day. However, in animals thymectomized and subsequently x irradiated, all the tumor grafts grew (10/10), though 7 of them were later rejected, but their survival time was significantly prolonged. It thus appears that the regeneration of immune competence following whole-body x irradiation is impaired in thymectomized animals. (P.C.H.)

**10413** CHANGES IN CLEARANCE OF $Fe^{59}$ FROM PLASMA IN THE INITIAL STAGE OF BONE MARROW INJURY AFTER SUBLETHAL TOTAL-BODY IRRADIATION. R. Stodtmeister, T. M. Fliedner, and M. Dietrich (Universität Heidelberg). Folia Haematol. (Frankfurt), 6: 252-5 (Oct. 1961). (In German)

Bone marrow function was assessed by the disappearance of injected $Fe^{59}$ from the plasma of rats given 600 to 800 r $Co^{60}$ irradiation (~$LD_{50}$ at 30 days) or 1000 r ($LD_{100}$). The isotope studies were supplemented with histological examination of the marrow. After a single whole-body $LD_{\infty}$ dose the marrow showed edema and massive hemorrhage, accompanied by disruption of capillary sinusoids. This was followed by an occlusion of the marrow vascular system that persisted up to about 10 days after irradiation. Mar-

row insufficiency was also evident from the greatly prolonged half time of plasma $Fe^{59}$ clearance of 350 min, compared with the normal value of 90 min. This is a reflection of the marked destruction by radiation of marrow parenchymal cells. The $Fe^{59}$ clearance curve shows an early inflection point at about 25 to 30 min after injection (indicating an initial half time of 15 to 20 min), then declines very slowly thereafter. (H.H.D.)

**10414** EFFECT OF PATERNAL IRRADIATION ON 154 DAY WEIGHT IN SWINE. R. L. Willham and D. F. Cox (Iowa State Univ., Ames). Genetics, 47: 1639-46(Dec. 1962).

The testes of male swine were exposed once to 300 r of x rays. The males were allowed to recover before they were used for breeding so that the sperm sampled were irradiated as spermatogonia. Exposed males, when bred to females purchased from breeders, sired offspring that had a significantly lower weight at 154 days of age than the comparable controls. Exposed males, bred to females that were from litters produced by the purchased animals, sired offspring having a significantly higher weight at 154 days than the controls. These data suggest that the genetic effect of irradiation may interact with combinations of circumstances, perhaps of both genetic and environmental origin. (auth)

**10415** INDUCED CHANGES IN FEMALE GERM CELLS OF DROSOPHILA. VII. EXCHANGES INDUCED IN DIFFERENT X CHROMOSOME REGIONS AFTER X-RAYING OOCYTES AND OOGONIA. I. H. Herskowitz, A. Schalet, and Mary Del Val Reuter (St. Louis Univ.). Genetics, 47: 1663-78(Dec. 1962).

Following exposure of germ cells of female D. melanogaster either to 3000 to 4000 r or to no dose of x rays, induced exchanges involving proximal or distal regions of the X chromosome were detected in $F_1$. The genetic markers employed in the present and earlier work permitted the determination, for cells in different stages of oogenesis, of induced exchanges involving four regions of the X chromosome (y-spl, f-car, car-su-f, and su-f-right telomere). From the results of various tests of recombinant $F_1$ in these experiments and others, it was possible to estimate the relative contributions of point deletions, half-translocations, pseudo-crossovers resulting in the formation of attached-X's, and crossover-like exchanges (composed of crossovers and/or pseudocrossovers) to the induced exchange rates observed. The results support the view that x-ray-induced recessive lethal mutants in oocytes typically arise as the result of events which involve only a single strand of a tetrad. (auth)

**10416** RADIATION USES IN AGRICULTURAL GENETICS IN THE UNITED ARAB REPUBLIC. Intern. At. Energy Agency Bull., 5: 22-4(Jan. 1963).

A review is given of a program developed in the United Arab Republic for the study of genetic effects of different types of radiation on cell tissues and of the influence of irradiating either seeds or growing plants on the rate of growth of agricultural crops. Discussion is given on the irradiation experiments, experimental facilities, and training of personnel in the program. (P.C.H.)

**10417** FALL IN THRESHOLD TO ELECTRICAL EXCITATION OF X-IRRADIATED ISOLATED FROG NERVE. D. Rosen and K. B. Dawson (Royal Cancer Hospital, London) Intern. J. Radiation Biol., 5: 535-41(Oct. 1962).

Monophasic action-potentials were recorded in isolated frog sciatic nerves in a humid chamber; constant electric stimuli were given in each experiment at a regular rate of between 12 and 30 stimuli per minute. Preparations were irradiated with 50 kv x rays delivered at a rate of 67 krad/min and were given doses of between 11 and 23 krad. Submaximal action-potentials showed an increase of size within 2 sec of commencement of irradiation, and the increase persisted for at least 15 min after the end of the irradiation. The increase was caused by a fall in threshold of the axons in the nerve trunk. However, irradiation did not affect the size of maximal action-potentials, did not produce any gross change of shape in the action-potentials, and did not allow ephaptic transmission between adjacent axons in the nerve trunk. (auth)

**10418** THE EFFECT OF METHYSERGIDE AND X-IRRADIATION ON THE BARBITURATE SLEEPING-TIME IN RATS. V. Varagić, S. Stepanović, and S. Hajduković (Boris Kidrich Inst. for Nuclear Sciences, Belgrade and Medical Faculty, Belgrade). Intern. J. Radiation Biol., 5: 559-65(Oct. 1962).

Methysergide (1-methyl-D-lysergic acid butanolamide bimaleate), a highly potent and specific 5-hydroxytryptamine antagonist, if injected after irradiation, significantly depresses the prolonging effect of x irradiation on the barbiturate sleeping-time in rats. Lysergic acid diethylamide did not show this type of activity. 5-Hydroxytryptamine, when injected before irradiation, did not depress the typical response of the irradiated animals to barbiturates. When used after irradiation, 5-hydroxytryptamine caused a further prolongation of the barbiturate sleeping-time. Cysteamine, when injected before irradiation, depressed or blocked the prolonging effect of x irradiation on the barbiturate sleeping-time. When injected after irradiation, cysteamine was found to cause a further prolongation of the barbiturate sleeping-time. The mechanisms of action of methysergide, 5-hydroxytryptamine, and cysteamine are briefly discussed. (auth)

**10419** THE OXYGEN-CONCENTRATION AT WHICH A RESPONSE OF SPECIFIED MAGNITUDE IS OBTAINED IN IRRADIATION EXPERIMENTS WITH PSEUDOMONAS AERUGINOSA. A. A. van Soestbergen (National Defence Research Organization T.N.O., Rijswijk (Z.H.), Netherlands). Intern. J. Radiation Biol., 5: 567-77(Oct. 1962).

The effect of x irradiation at various oxygen-concentrations was examined in a strain of Pseudomonas aeruginosa. The relationship between the logarithm of the oxygen-concentration and the fraction of the bacterial population surviving a given fixed value of the radiation dose can be adequately described by a simple transformation of the equation of a cumulative normal curve. This has already been demonstrated in the case that the dose-survival curve is linear on a logarithmic plot (van Soestbergen 1962). The present investigation confirms this observation with data derived from an experiment where the dose-survival curve is of a non-linear type. It is shown that the oxygen-concentration at which a response of specified magnitude is obtained decreases exponentially with the radiation dose. The radiosensitivity of the bacterial population, defined as a function of the oxygen-concentration at which an effect of specified magnitude is obtained, increases exponentially with the radiation dose. (auth)

**10420** RESPONSE TO GAMMA-RADIATION OF MOUSE EMBRYONIC LUNG CULTIVATED IN VITRO. Tommaso Alescio and Mario Ladu (Comitato Nazionale per l'Energia Nucleare, Frascati, Italy). Intern. J. Radiation Biol., 5: 579-89(Oct. 1962).

The radiation response of mouse embryonic lung-rudiments during 48 hours of cultivation in vitro was studied. The reaction appears to consist of the succession of two phases. The first phase lasts about 12 hours after ir-

radiation, and may be defined as epithelial phase as it shows degenerative changes of the epithelium, originating in the trachea and then gradually spreading in a distal direction as far as the terminal buds. In this phase no mitoses are observed either in the epithelium or in mesenchyme. The second phase begins with resumption of mitotic activity and shows regenerative phenomena in the epithelium, which, however, maintains signs of diffuse cytological changes. At the same time pycnotic degeneration appears in the mesenchyme and invades it throughout, so that this phase can be called mesenchymal. (auth)

**10421** AGE-RELATED FACTORS WHICH INFLUENCE THE VALUE OF THE MOUSE EMBRYO FOR POST-IRRADIATION RESTORATION OF THE ADULT. J. F. Duplan (Institut du Radium, Paris) and N. S. Wolf. Intern. J. Radiation Biol., 5: 597-607(Oct. 1962).

Strain XVII mice were given 800 r x irradiation. In one group of experiments this was followed by injection of either 12- or 13-day isologous cells from the whole embryo. All mice that received cells from the 12-day embryos died at approximately the same time as irradiated controls. Among those receiving 13-day-embryo cells there was a 64% 30-day survival rate. In a second group, lethally irradiated mice were given cells from either the liver and spleen or from the remainder of the carcass of 14-day fetuses, or, alternatively, from 18-day fetuses. The mice receiving liver and spleen cells from fetuses of either age enjoyed a good survival rate. Of animals treated with carcass, there were numerous survivals only among those receiving 18-day carcass. An attempt was made to explain the findings by histological investigation of both donors and recipients, and some possible explanations for the phenomena observed were advanced. (auth)

**10422** GROWTH AND SEXUAL DEVELOPMENT OF PRENATALLY IRRADIATED CATTLE. N. R. Parish, R. L. Murphree, and E. W. Hupp (Univ. of Tennessee-AEC Agricultural Research Lab., Oak Ridge). J. Animal Sci., 21: 473-8(Aug. 1962).

Pregnant Hereford and Hereford-Angus cows received 400 r (air dose) of gamma radiation from $Co^{60}$ at a rate of 24.9 r/hr. The average stage of gestation at irradiation was 202 days (range 122 to 235 days). Fetal irradiation caused a small decrease in growth rate, and 90% of the prenatally irradiated heifers were fertile when bred to normal bulls. Testis weights of the prenatally irradiated bulls were ~50% less than those of the control bulls when castrated at 187 days of age. In addition, bulls prenatally irradiated in the 5th or 8th month of fetal life produced 42% and 52% as many sperm as control bulls. Metabolic activity of the sperm from irradiated bulls did not differ from that of the control bulls. Six % of the dams died from acute radiation sickness (average 23 days postirradiation), whereas no mortality was observed in 34 bulls irradiated with 400 r. The failure to observe decreased fertility in mature cows within 3 or 5 years after 400 r, or 3 years after an accumulated dose of 800 r (400 r and 400 r 2 years later) is in contrast to decreased fertility in rodents following lower doses. This suggests that the ovaries of females of the larger species are less sensitive to irradiation than are the ovaries of rodents. (H.H.D.)

**10423** TREATMENT OF MOSQUITO LARVAE AND ADULTS WITH RADIOACTIVE PHOSPHORUS. W. W. Yates (Bureau of Entomology and Plant Quarantine), C. M. Gjullin, Arthur W. Lindquist, and Joseph S. Butts. J. Econ. Entomol., 44: 34-7(1951).

Studies were made to determine how to introduce radioactive phosphoric acid ($P^{32}$) into both larvae and adult mosquitoes in amounts that would be detectable with radioactive measuring devices. Aëdes sticticus (Meig.) and A. vexans (Meig.) mosquitoes gave 544 to 897 cpm above background after they had been allowed to feed on the blood of rats that had received 0.375 millicurie of $P^{32}$ in aqueous solution intraperitoneally 24 hours earlier. In three dissected specimens an average of 72 per cent of the radioactivity was found in the abdomen and 4 per cent in the legs. Second- and third-instar larvae of Culex tarsalis (Coq.) reared in water having an unknown concentration of $P^{32}$ had radioactivity ranging from 164 to 417 cpm. Fifteen per cent of this radioactivity was present in the legs and 45 per cent in the abdomen. Aëdes sticticus females fed on water having an unknown concentration of $P^{32}$ gave readings of 577 to 1,192 cpm 1 to 13 days later. The legs had approximately 9 per cent and the abdomens 41 per cent of the total radioactivity. Aëdes sticticus and A. vexans adults reared from the second-stage larvae in water containing 0.05 μc of $P^{32}$ per milliliter gave average readings of 41,147 cpm for females and 39,072 cpm for males. In later tests dosages of 0.01, 0.001, and 0.0001 μc per milliliter gave 14,911, 1,612, and 522 cpm, respectively, for the females. It is suggested that a concentration of approximately 0.0001 μc of radioactive phosphoric acid per milliliter may be a practical dosage for the treatment of larvae in flight studies of adults. Since adults may be readily tagged by feeding them sugar solutions containing small amounts of $P^{32}$, the use of this method may be desirable in many studies. (auth)

**10424** THE INFLUENCE OF X IRRADIATION EFFECTS ON THE IMMUNITY OF MICE TO INFECTION WITH TRICHINELLA SPIRALIS. Allen Yarinsky (New York City Dept. of Health). J. Elisha Mitchell Sci. Soc., 78: 29-43(May 1962).

In mice irradiated with 50, 250, 450, or 650 r 24 hr prior to a single infection with 200 T. spiralis larvae, no interference in the development of acquired immunity was noted 14 days postinfection. However, interference with the maintenance of immunity was noted at 20 and 28 days in those exposed to 450 and 650 r. In general, mice showing a normal immune response showed a pattern of weight loss and later gain associated with the stress of intestinal inflammation. When similar doses of irradiation were given to previously immunized mice 24 hr prior to a challenge infection, there was no interference with the maintenance of acquired immunity by 7 days postchallenge. However, after high doses (450 and 650 r), interference with immunity was evident at 14 days. Recovery of immunity was evident within an additional 2 weeks. Interference with acquired immunity was demonstrated in immunized mice at 7-day necropsy when the schedule of irradiation (450 r) was altered so that the 7-day necropsy was equivalent to the 14-day period in the previous experiment. It is suggested that radiation interferes with 1 or more phases of the intestinal inflammatory response. Irradiation effect on acquired immunity appears to be an indirect one brought about by damage to the hematopoietic system, which is thereby unable to supply the large numbers of cellular elements needed to initiate and maintain an effective inflammatory response. (P.C.H.)

**10425** THE ROLE OF HUMORAL ANTIBODIES IN REJECTION OF SKIN HOMOGRAFTS IN RABBITS. II. PASSIVE TRANSFER OF TRANSPLANTATION IMMUNITY BY SENSITIZED LYMPH NODE CELLS WITHIN DIFFUSION CHAMBERS. Roberto R. Kretschmer and Ruy Pérez-Tamayo (Univ. Nacional Autónoma de Mexico, Mexico City). J. Exptl. Med., 116: 879-96(Dec. 1, 1962).

Transplantation immunity was successfully transferred

to rabbits by sensitized lymphoid cells enclosed in Millipore chambers in x-irradiated and nonirradiated recipients. The chambers allowed antibody to diffuse from the cells contained therein. In nonirradiated rabbits graft rejection time was reduced by 2.8 days. Irradiation of rabbits with 400 or 800 r significantly reduced the rejection time. A dose of 400 r whole-body radiation in rabbits depressed only the immune response mediated by humoral antibodies, while the delayed form of hypersensitivity to the same antigen remained unaltered. On the other hand, 800 r depressed both forms of the immune response. The data suggest that the effect of radiation on skin homografts in the rabbit is due to the suppression of humoral antibodies, since doubling the dose of x rays with the consequent blocking of delayed hypersensitivity had no further influence on the average time of homograft survival. The fact that passive transfer of transplantation immunity, by means of sensitized lymphoid cells enclosed within diffusion chambers, was accomplished in nonradiated and radiated rabbits indicates that humoral antibodies play an important role in rejection of skin homografts in the rabbit. (H.H.D.)

**10426** INFLUENCES OF β-MERCAPTOETHYLAMINE AND OXYGEN REMOVAL ON THE X-RAY SENSITIVITY OF FOUR STRAINS OF ESCHERICHIA COLI. H. L. Cromroy and H. I. Adler (Oak Ridge National Lab., Tenn.). J. Gen. Microbiol., 28: 431-5(1962).

In four strains of Escherichia coli B/r (ORNL), B (ORNL), B (Hill), and Bs (Hill) protection against x irradiation by β-mercaptoethylamine (MEA) exceeded that observed for oxygen removal by nitrogen bubbling. Although only a slight decrease of protection was found with strain Bs (Hill) when oxygen was removed by nitrogen bubbling, the protection afforded by MEA in excess of that achieved by nitrogen bubbling was similar with all four strains. The data suggest that at least two mechanisms for protection by MEA may operate simultaneously in some bacteria and that one of these is a removal of oxygen equivalent to that achieved by nitrogen gas bubbling. (auth)

**10427** VIRUS INFECTION AND X RADIATION: A COMPARATIVE STUDY OF INFECTION WITH AN ATTENUATED VENEZUELAN EQUINE ENCEPHALOMYELITIS VIRUS AND OF X RADIATION. Charles C. Berdjis, Chester A. Gleiser, William S. Gochenour, and Trygve O. Berge (U. S. Army Medical Unit, Fort Detrick, Md.). J. Infect. Diseases, 109: 62-70(July-Aug. 1961).

A study on guinea pigs infected with VEE virus and an attenuated strain (TC-50) of VEE revealed that a similarity exists between the effects of the virus infection and whole-body x irradiation on lymphatic systems and bone marrow. VEE virus and x rays exert a selective effect upon the tissues. The effect of x radiation (175 r) was immediate and dramatic, whereas that of TC-50 was slower, especially in bone marrow. The thymus, markedly depleted in irradiated animals, seemed to be spared by the virus. Secondary depletion was observed at day 13 in the irradiated group and was absent in the TC-50 group. There was a sharp difference during the first 2 days between irradiated and TC-50-treated guinea pigs whereas findings on the 3rd, 4th, and 5th days were almost identical in both groups. The time factor was also important in the rate of recovery, especially for bone marrow. The bone marrow of TC-50-inoculated animals failed to show the secondary depletion observed in irradiated groups. The selective effect of the attenuated virus upon the lymphatic organs and bone marrow is contrasted with the relative affinity of the mother virus (VEE) for central nervous system. This attenuated virus seemed to lose its neurotropism. (H.H.D.)

**10428** ANTIRADIATION COMPOUNDS. II. DITHIOCARBAMATES. William O. Foye and James Mickles (Massachusetts Coll. of Pharmacy, Boston). J. Med. Pharm. Chem., 5: 846-52(July 1962).

Substituted dithiocarbamic acid derivatives, some of which contain metal-chelating functions additional to the dithiocarbamyl group, were synthesized as potential protective agents against ionizing radiation. It appeared that the additional nitrogen-containing chelating function contributed nothing to the radioprotective ability of dithiocarbamates. The derivatives did not approach MEA dithiocarbamic acid in protective ability. However, significant protection (35 to 40% increase in survival over that of the controls) was afforded by a number of the dithiocarbamic acid derivatives when injected 30 min prior to a radiation dose of 575 to 600 r. The phenyl derivative was completely inactive, but the cyclohexyl analog showed significant protection. Both the β-diethylaminoethyl and β-hydroxyethylaminoethyl derivatives, as well as the piperazine derivatives showed some protection, but the dimethylaminopropyl derivative was without protective ability. Radiation protection of Escherichia coli cells was assayed using the dithiocarbamic acid derivatives, but no protection was observed except with the β-hydroxyethylaminoethyl and β-aminoethylpiperazine derivatives. Several of the compounds proved to be unexpectedly toxic in mice. No correlation between dosage and protective ability was evident. All of the dithiocarbamates tested were found to chelate both cupric and ferric ions. However, inclusion of additional nitrogen-containing groups, to provide possible tridentate chelates, did not appear to increase their protective ability. (P.C.H.)

**10429** SERUM ACTION ON RADIATION RESPONSE IN TISSUE CULTURE. Hector Montes de Oca, Edward L. Schilling, Jay C. Bryant, Virginia J. Evans, and Wilton R. Earle (National Cancer Inst., Bethesda, Md.). J. Natl. Cancer Inst., 30: 57-66(Jan. 1963).

This study explores the action of serum in the radiation response of strain NCTC 2071 cells cultured in a medium free of serum or protein through more than 294 subculture generations for over 6 years. Since it is difficult, if not impossible, to wash serum completely from cells, even with multiple saline rinses, cells of this strain were ideal for this study. Cells in agitated fluid-suspension cultures on the Brunswick shaker for 28 days were used. It was shown that serum modified the radiation response by speeding recovery of the irradiated cultures when serum was added either before or immediately after irradiation; such cells began to recover at 10 days after irradiation. Cells irradiated in medium NCTC 109 without serum, however, usually did not resume growth, or if they did, it was only after 28 days. The mechanism of this action of the serum is discussed. (auth)

**10430** MAZE PERFORMANCE AND FIXATED BEHAVIOR IN THE RAT AFTER CRANIAL X IRRADIATION. Oddist D. Murphree, Chalmers S. Pool, and Thomas T. Frost (Veterans Administration Hospital, North Little Rock, Ark.). J. Nervous Mental Disease, 132: 304-6(Apr. 1961).

Portions of the cranium of rats were irradiated with 1760 r, other areas being shielded. The eyes of the rats were then removed and 90 days postirradiation learning trials were conducted in a Stone 14 choice-point multiple T maze. The immediate postirradiation response consisted mainly of several days of lethargy and drowsiness followed by gradual return toward usual behavior. Learning performances of control and irradiated groups did not differ in errors committed in the region of relatively high performance levels between trial 13 and 32, the region of fast-

est learning. The Wald-Wulfowitz Runs Test showed that the rates of extinction were not different between control and irradiated animals. Histologic examination of the brains 12 months after irradiation showed no lesions of either the nervous tissue proper or of the vessels. It was concluded that: mild brain damage of this type is not a serious factor in fixation development and extinction; the mild brain damage did impair maze performance; slightly impaired intellectuality is not an important factor in fixation development; and vision is not important for fixations of this kind. (H.H.D.)

**10431** MORTALITY OF X IRRADIATED MICE INFECTED WITH TRICHINELLA SPIRALIS. Allen Yarinsky (New York City Dept. of Health). J. Parasitol., 48: 156-7 (Feb. 1962).

Swiss mice were given 250, 350, 450, or 650 r and infected orally with 50, 100, or 200 larvae 24 hr after exposure to radiation. Radiation doses of 250 and 350 r followed by infection did not result in host mortality throughout the 28-day observation period. One death occurred 24 days after 450 r in the group of 32 mice infected with 100 worms, but all mice that received 200 worms after similar irradiation exposure survived. Fifteen of 24 mice given both 650 r radiation and infection died, whereas 1 of 8 animals died that had received only radiation. Thus infection with 50 to 200 worms given 24 hr after 650 r whole-body x radiation resulted in a greater likelihood of death than when the infection was omitted. It is suggested that the worms, by their migrations within the intestinal tissues, opened the way for bacterial invasion via the intestine, resulting in bacteremia. This would account for the higher mortality the 2nd week after moderately lethal irradiation doses. (H.H.D.)

**10432** ISLET-CELL TUMORS OF THE PANCREAS IN THE IRRADIATED AND NONIRRADIATED RAT. Victor J. Rosen, Jr., T. J. Castanera, D. C. Jones, and Donald J. Kimeldorf (Naval Radiological Defense Lab., San Francisco). Lab. Invest., 10: 608-16(May-June 1961).

Adult male rats were irradiated with high sublethal (430 rad) or midlethal (680 rad) doses of x rays, and their tissues were examined histologically after spontaneous death. Of 141 irradiated rats, 18% developed pancreatic islet cell tumors, compared with 9.8% in unirradiated controls. Those receiving 430 rad had 19.0% and those receiving 680 rad had 17.2% incidences of the same tumor. All animals with islet cell tumors, except 1 control and 1 irradiated rat, had other endocrine neoplasms. Morphologically, the tumors resembled giant islets of Langerhans and were composed predominantly of beta cells. About half of the tumors showed some degree of capsular invasion. The tumors may arise de novo from pancreatic ductal epithelium as do normal islets, or, secondly, they may represent adenomatous transition or marked hyperplasia of pre-existing islets. Whether the increased frequency of islet cell tumors in the irradiated animals is due to a direct radiation effect on the islet cells or ductal epithelium or to indirect effects via other endocrine disturbances is unknown. (H.H.D.)

**10433** PATHOGENESIS OF POST-IRRADIATION GLOMERULOSCLEROSIS IN MICE. Victor J. Rosen, Leonard J. Cole, and Patricia L. Roan (Naval Radiological Defense Lab., San Francisco). Lab. Invest., 10: 857-64 (Sept.-Oct. 1961).

Renal glomerular lesions were studied histologically in $LAF_1$ mice given 690-rad whole-body x radiation. The lesion was manifested by the proliferation of large, irregular pleomorphic cells in the intercapillary space, and by the subsequent deposition of PAS-positive material in these areas and in the glomerular basement membranes. The lesion appeared after a latent period of about 20 weeks and progressed rapidly from that time. Kidneys of nonirradiated $LAF_1$ mice 18 to 24 months old showed the development of lesions morphologically similar to but less severe than those observed in the mice examined more than 20 weeks after irradiation. Proliferated intercapillary cells in the glomerular lesion were much more bizarre and pleomorphic in the young irradiated mouse than in the senile nonirradiated mouse. It is suggested that the similar but less severe lesions seen in nonirradiated aged $LAF_1$ mice may imply that the irradiation lesion is a manifestation of a premature aging phenomenon in the kidney although acceleration of what may be a spontaneous form of glomerulitis must also be considered. (P.C.H.)

**10434** MODIFICATION OF THE FOREIGN SPLEEN REACTION: AMELIORATION OF BLOOD AND TISSUE CHANGES. R. L. DeHart (Univ. of Tennessee, Memphis), G. E. Cosgrove, and A. C. Upton. Lab. Invest., 10: 872-82(Sept.-Oct. 1961).

A comparison was made of histologic and hematologic changes in 2 groups of lethally irradiated mice implanted with parental-strain spleen cells. In 1 group the spleen cells were incubated with liver of the recipient strain in an attempt to prevent the cells from causing subsequent detrimental reactions in the recipients, and in the 2nd group untreated spleen cells were transferred. Inactivation of C57BL spleen cells by their incubation with recipient-type (C57BL × 101) $F_1$ liver inhibited the blood and tissue changes otherwise occurring when such cells were injected in sublethally irradiated (C57BL × 101) $F_1$ mice. In recipients of such inactivated cells, hemopoietic regeneration was enhanced and the granulomatous reaction in the lymphoid tissues was reduced. It is inferred that pre-exposure of the grafted cells to recipient cells, or their antigens, lessened their ability to react subsequently against the host. The observed inactivation process may involve alteration of the donor antibody-forming cells by an excess of recipient antigens present in the incubation tissue. (H.H.D.)

**10435** CHROMOSOME DAMAGE IN AN INFANT AFTER DIAGNOSTIC X IRRADIATION. P. E. Conen (Hospital for Sick Children, Toronto). Lancet, 2: 47(July 1, 1961).

Chromosome anomalies were detected in bone-marrow and blood cells of a 7-week-old infant who had been subjected to 22 diagnostic x-ray exposures 1 to 2 months previously. The counts showed a modal number of 46 but a higher incidence of non-modal counts than normally seen. In addition, definite structural chromosome abnormalities including dicentrics and probable chromatid deletions were recognized. The findings substantiate previous work in which a dicentric chromosome was found in 2 out of 31 cells of a leukocyte culture from an irradiated patient. (H.H.D.)

**10436** A POSSIBLE ASSOCIATION BETWEEN MATERNAL RADIATION AND MONGOLISM. Irene A. Uchida and Elizabeth J. Curtis (Children's Hospital, Winnipeg, Manitoba). Lancet, 2: 848-50(Oct. 14, 1961).

Replies to questionnaires sent to the parents of 53 mongoloid children, inquiring about any radiation they had received before the child had been born, suggested a strong association between mongolism and radiation of the mother. The mothers were divided into 3 groups: those who had no abdominal x rays before conceiving the child; those with less than 4 exposures (usually 1 or 2); and those with 4 or more. Fluoroscopic examinations of the abdomen were included in the last group. The data are highly heterogeneous between the last category and the first two. Thus the frequency of heavy irradiation differed significantly in the

3 groups. Furthermore, when the mongoloid families were compared with the control group the difference was highly significant. The frequency of multiple abdominal irradiation was more than 7 times greater in the mongoloid compared with cleft-lip (control) families. It was concluded that the data show a close association between the incidence of mongolism and maternal abdominal irradiation. Familial cases of mongoloidism were excluded. (P.C.H.)

**10437** RECOVERY FROM LETHAL IRRADIATION IN RATS AFTER INTRAVENOUS ADMINISTRATION OF ISOGENIC LYMPHOCYTES. E. J. Delorme (Chester Beatty Research Inst., London). Lancet, 2: 855-7(Oct. 14, 1961).

Rats of an inbred strain, possessing genetic uniformity to exchange skin grafting, were subjected to 1000 r irradiation. All 30 untreated control animals died within 30 days. In 37 animals given 100 to 150 $\times 10^6$ isogenic bone-marrow cells within 24 hr of irradiation the survival rate was 54%. In 21 animals given comparable doses of isogenic thoracic-duct lymphocytes collected under refrigeration the survival-rate was 43%. There appeared to be a minimal number of cells (about 90 $\times 10^6$) required for protection, but multiple infusions increased rather than decreased the mortality. The nonspecific protective factor in cell-free deoxyribonucleic acid was discounted, because lymphocytes disrupted by ultrasonic waves showed no protective activity. (P.C.H.)

**10438** IRRADIATION OF CEREBRAL ASTROCYTOMATA UNDER WHOLE-BODY HYPOTHERMIA. M. Block, H. J. G. Bloom, J. Penman, and Lawrence Walsh (St. George's Hospital, London). Lancet, 2: 906-9(Oct. 21, 1961).

Fourteen cases of cerebral glioblastoma multiforme (astrocytoma grades III and IV) were treated by irradiation under mild hypothermia (30 to 33°C). It is shown that under hypothermia, cerebral tissues become more sensitive to x rays. A differential sensitivity, favorable to treatment, may exist between tumor and normal tissue cells. Because irradiation under hypothermia is followed by signs of acute cerebral edema, the total incident dose to each hemisphere, in any single course of treatment, had to be limited to 300 to 450 r (given as 150 r daily). With these doses it was not possible to prolong life beyond what would be expected from surgery alone. Experiments on mice support the view that mild hypothermia increases tissue radiosensitivity. Well-oxygenated tissues are considered to be practically at their maximum sensitivity, and no appreciable increase in response to irradiation is expected to follow a further rise in oxygen tension. Because of some more generalized cerebral reactions, and the rise in mortality in mice after whole-body irradiation under hypothermia, it appears likely that the increased response to irradiation during mild hypothermia is not entirely due to an increase in oxygenation of the tissues. It is advised that low doses be used in commencing any course of treatment involving irradiation under hypothermia. (P.C.H.)

**10439** POSTOPERATIVE IRRADIATION OF CORNEAL GRAFTS: ITS POSSIBLE EFFECT ON THE IMMUNOLOGICAL REACTION. D. Ainslie and Margaret D. Snelling (Middlesex Hospital, London). Lancet, 2: 954-6(Oct. 28, 1961).

Strontium-90 beta irradiation completely prevented unwanted vascularization in 13 out of 16 corneal grafts and thus opacity as a result of blood vessel invasion of the graft was avoided. The results suggest that damage to the grafted donor cornea is due to a local rather than a general immune reaction on the part of the host. Probably, this consists only of the response of the recipient to the antigens in the donor cornea, and the latter contains no cells or antibodies capable of reacting to the antigens of the host. If this is so, there need be no concern about the possible reaction of the donor cornea to the host's antigens. It is suggested that mesenchymal cells, capable of reacting with the antigens of the donor cornea, grow into the grafted tissue with the blood vessels. If the cells are destroyed by irradiation, however, the reaction cannot take place. This suggests that fixed antibody may be responsible for the reaction. (H.H.D.)

**10440** RADIATION NEPHRITIS: A LONG-TERM STUDY OF 54 PATIENTS. R. W. Luxton (Christie Hospital, Manchester, Eng.). Lancet, 2: 1221-4(Dec. 2, 1961).

Radiation nephritis may result when the kidneys are included in therapeutic fields of deep x rays. In 54 patients observed over 13 yr, initial clinical presentations were acute radiation nephritis (20 cases), primary chronic radiation nephritis (10), benign hypertension (6), late malignant hypertension (5), and proteinuria (13). In acute radiation nephritis the immediate prognosis was related to the occurrence of malignant hypertension from which spontaneous recovery followed in 2 patients. After recovery from the acute phase, chronic nephritis always remained. Chronic radiation nephritis may develop insidiously (primary chronic radiation nephritis) or it may follow acute radiation nephritis (secondary chronic radiation nephritis). The ultimate prognosis may be better in the secondary type. Of 6 patients with benign hypertension syndrome, 2 died of congestive heart failure and 1 of malignant hypertension. Proteinuria alone, after renal irradiation, may denote a latent form of nephritis. Of the 54 patients, 15 (28%) developed malignant hypertension sooner or later. Thus the study supports the concept obtained from animal experiments that x irradiation of the kidneys has 2 distinct and independent biological effects: hypertension and interstitial fibrosis. (H.H.D.)

**10441** MALIGNANCY OF THE TUBERCULAR LUPUS AFTER APPLICATION OF MASSIVE DOSES OF X-RAYS. S. Leizeraha. Latvijas PSR Zinatnu Akad. Vestis, No. 6, 119-21(1962). (In Russian)

It was frequently reported in the literature that the lupus carcinoma occurs frequently as a complication of the tubercular lupus; some authors ascribed the cancerous degeneration of the skin of these patients to exposure to x rays. It was assumed that development of the carcinoma starts long before the clinical picture appears. Among the 367 tubercular lupus patients at the Bone Tuberculosis Hospital and the Antituberculosis Dispensary of the Latvian Republic, observed during the years from 1951 to 1959, lupus carcinoma was found in 11 cases. All these patients were women between the ages of 28 to 64 years, and all had the sickness for periods ranging from 6 to 40 years. Four patients had surface sores, five presented ulcerous and two hypertrophic lupus. The carcinoma was found on the face of the patients in every case. Ten of the patients were subjected only to x ray treatment previously. Although the number of the cases was small, it was concluded that repeated exposure to x radiation is responsible for the development of the carcinoma. (TTT)

**10442** THE EFFECT OF IRRADIATION ON PLANTS TREATED WITH VARIOUS NITROGEN FERTILIZERS. A. Millers. Latvijas PSR Zinatnu Akad. Vestis, No. 7, 85-90(1962). (In Latvian)

A positive effect of radiation on the growth rate of the plants was noted when grain and sugar beet seeds were irradiated before planting with small doses of $\beta$ and $\gamma$ rays; this effect was more pronounced when nitrate, rather than ammonium, fertilizers were used. It was also found that the activity of polyphenoloxydase in the irradiated plants

increases with a $NO_3^-$ background and decreases with a $NH_4^+$ background. The nitrate fertilizer promoted the collection of vitamin C and sugar in the irradiated plants. Exposure of the sugar beet seeds to radiation before planting resulted in an increase of the yield and of the sugar content in the roots, especially if the nitrogen was supplied by means of a nitrate fertilizer. This reversal of the effect of radiation by the various types of nitrogen fertilizer should be taken into consideration when preparing radiobiological experiments. (TTT)

**10443** COMPARATIVE DISTRIBUTION OF COLLOID SOLUTIONS OF SALTS OF RADIOACTIVE YTTRIUM IN ANIMALS DURING INTRAPERITONEAL ADMINISTRATION. M. A. Volkova, S. G. Pelman, and S. L. Daryalova (Gertsen State Oncological Inst., USSR). Med. Radiol., 7: No. 12, 3-7(Dec. 1962). (In Russian)

Data relative to the distribution of colloid solutions of salts of radioactive yttrium silicate, phosphate, and fluoride in experimental intraperitoneal introduction are reported. The radioactivity of tissues (blood, liver, spleen, heart, lungs, kidneys, peritoneum, retroperitoneal cellular tissue, mediastinal cellular tissue, and bone) after the administration was studied at different periods ranging from 1 to 72 hr. A colloid solution of yttrium silicate (size of particles 70 mμ) differed from other solutions by a relatively rapid penetration into the liver, spleen, and cellular tissue of the mediastinum. A solution of yttrium fluoride (size of particles 150 to 170 mμ) remained for a more prolonged time at the site of introduction. No tropism of solutions of Y salts to bone was noted. (auth)

**10444** STUDIES OF PERIPHERAL VESSELS IN PERSONS WORKING ON THE CYCLOTRON. V. V. Alferova and L. V. Kuznetsova. Med. Radiol., 7: No. 12, 32-7(Dec. 1962). (In Russian)

The reaction of peripheral vessels of the hand to a photothermal stimulus with simultaneous plethysmographic recording of the other hand in a number of persons working with the cyclotron and in a control group was investigated. The results show that in persons working with the cyclotron there is an altered form of phone plethysmogram, the nature of which is stable in some instances, and unstable in others. (P.C.H.)

**10445** CHANGES OF LEUKOCYTE MOTILITY IN RADIUM THERAPY. A. V. Kovalenko (Kirov Military Medical Academy, USSR). Med. Radiol., 7: No. 12, 38-40(Dec. 1962). (In Russian)

A study was made on the motility of neutrophils during Roentgen and Curie therapy. Low doses of ionizing radiation at first increase the motility of leukocytes. Total doses after repeated irradiations, along with a reduction of the total leukocyte count, caused a noticeable decrease of their motility in comparison with the initial values before irradiation. Studies of the leukocyte motility by the method of phase-contrast microscopy may be used for the assessment of the functional activity of leukocytes during the effect of radiations on the human organism. (P.C.H.)

**10446** CHARACTERISTICS OF BLOOD COAGULATION DISTURBANCES IN CHRONIC (OCCUPATIONAL) X-RAY IRRADIATION. V. I. Shevchenko (Altai Medical Inst., USSR). Med. Radiol., 7: No. 12, 49-55(Dec. 1962). (In Russian)

The bleeding and clotting time, plasma recalcification time, heparin tolerance, free heparin, prothrombin consumption, activity of plasmatic factors of thromboplastin, thromboplastin-generation test, activity of proaccelerin and proconvertin, blood clot retraction, thrombocyte count, and in some cases the content of serotonin were studied in 70 persons subjected to chronic occupational x irradiation. Prolongation of the recalcification time, decrease of prothrombin consumption, activity of plasmatic factors of thromboplastin, and impairment of thromboplastin formation were recorded. Less pronounced were the diminution of serotonin, activity of proaccelerin and proconvertin, prothrombin time, and reparin tolerance. Clot retraction and free heparin did not change. (P.C.H.)

**10447** THE VALUE OF HEMATOLOGICAL PICTURE IN THE EVALUATION OF OCCUPATIONAL INJURY FROM IONIZING RADIATIONS. B. Bellion and A. Masoero (Università Turin). Minerva Nucl., 6: 284-90(Sept. 1962). (In Italian)

The effects of ionizing radiation on hematopoietic tissue have long suggested hematological examination as a means of evaluating occupational injury. The value of such an examination as a guide to the suitability of certain types of work and the occupational risks involved are discussed in the light of the literature. The last part of the article is devoted to a discussion of the legal provisions and various recommendations made by the authorities concerned with this problem. Emphasis is given to the value of the results already obtained from hematological examinations. (auth)

**10448** USE OF COLUMNAR RECOMBINATION FOR DETERMINATION OF RELATIVE BIOLOGICAL EFFICIENCY OF RADIATION. M. Zielczynski. Nukleonika, 7: 175-82(1962). (In Russian)

A method for specific ionization measurements in a tissue-equivalent chamber is proposed. The measurement of specific ionization is a number of recombined ions in the chamber, if there are conditions for columnar recombination. Provided adequate tension on the chamber's electrodes is maintained, the method allows the determination of deep relative biological efficiency of unknown radiation compounds. (auth)

**10449** COMPLICATIONS OF INTENSIVE RADIATION THERAPY FOR CERVICAL CARCINOMA, WITH EMPHASIS ON SUPERVOLTAGE RADIATION AND SUPPLEMENTAL RADICAL PELVIC OPERATION. Frank C. Greiss, Damon D. Blake, and Frank R. Lock (Bowman Gray School of Medicine, Winston Salem, N. C.). Obstet. Gynecol., 18: 417-29 (Oct. 1961).

A comparison was made of the complications following conventional and telecobalt radiotherapy of 73 patients with cervical cancer. The most frequent complication of telecobalt therapy was subcutaneous lignification, which occurred in 24% of the patients. Other severe reactions were noted in bladder (5%), rectum (5%), and vagina (4%). Fracture of the femoral neck occurred in 5%, infection in 5%, and death (attributable to therapy) in 2%. No severe skin changes were noted below the 4000-r level, but 60% of patients receiving 4000 to 4999 r and 75% receiving 5000 r or more developed acute or severe chronic skin reactions. The changes are more likely to occur with high dosage increment, 500 to 600 r every fourth day, rather than with an increment of 300 r every second day. It is suggested that supervoltage radiation must be limited to the known tolerance of the exposed organs, including the subcutaneous tissue. At intensive dose levels the frequency and severity of complications precludes continuation of such therapeutic programs, such as additional radiation or radical operation for persistent cancer. A total lateral pelvic wall dosage of 5000 r, including intensive intracavitary radiation, is the suggested tentative limit above which complications increase markedly. (H.H.D.)

**10450** EXPERIMENTAL HOMOIO- AND HETERO-TRANSPLANTATION OF BLOOD VESSELS STERILIZED

BY GAMMA IRRADIATION. H. Rykowski (Experimental Surgical Inst., Polish Academy of Sciences, Warsaw). Orv. Hetilap, 103: 2197-2201(Nov. 18, 1962).

The histological structure of elasticity in previously infected arteries sterilized by gamma radiation remained unchanged. The time required for sterilization was 3 to 10 min for strong and 45 to 90 min for weak radiation. Transplantations with the irradiated arteries were successful. Use of blood vessels kept in a bacterial culture for 24 hr before irradiation were not suitable. In spite of sterilization, these were destroyed in 5 to 11 days after the transplantation. The complication was probably due to the proteolytic effect by the enzymes of the bacteria on the arterial wall. (OTS)

**10451** THE EFFECT OF YTTRIUM-90 ON THE PITUITARY. Jozsef Kovi (Univ. of Budapest). Orv. Hetilap, 103: 2277-80(Dec. 2, 1962).

Histological changes occurring in the pituitary after $Y^{90}$ implantation in cases of advanced breast carcinoma are reported. The adenohypophysis was 90-95% destroyed. Four zones can be distinguished around the radioactive material: complete radionecrotic; necrobiotic; reparative; periferal intact zone. (OTS)

**10452** CYTOLOGICAL AND MORPHOLOGICAL CHANGES INDUCED IN TOMATO AS A RESULT OF THERMAL NEUTRON IRRADIATION. C. C. Kuehnert (Univ. of Saskatchewan, Saskatoon). Radiation Botany, 2: 81-8(Nov. 1962). (In English)

Seeds of two species of tomato, Lycopersicon esculentum Mill. and L. pimpinellifolium Dunal were irradiated either for 20 hr at a flux of $7.63 \times 10^8$ thermal neutrons/cm$^2$/sec or for 30 hr at a flux of $7.63 \times 10^8$ thermal neutrons/cm$^2$/sec. Microscopic examination showed that the apex consisted of a two-layered tunica, which encloses a corpus. Examination of the apices from the irradiated series showed one or more modifications to occur: change of the plane of cell division occurring in the tunica region, such as periclinal divisions occur in the most centrally located cells of the first tunica layer; periclinal division of the cells of the second tunica layer in conjunction with such divisions occurring in the T-1 layer; complete disorganization of the second tunica layer so that the corpus continues unbroken from the first tunica layer; lysis of the most centrally located cells of the T-2 layer. Modifications of the corpus regions seen to occur were: an increasingly irregular organization of the planes of cell division; and earlier maturation of cells of the corpus as the result of either an acropetal advance of the inception of the vascular tissues or the inception of the pith rib meristem in closer proximity to the T-1 layer; this modification, in turn, appeared to exert an influence on the general outline of the generative region. The possible significance of the modifications is discussed. Radiation damage common to both growth zones was exemplified by collapse of the cells followed by a general tissue breakdown of that area of the apex. (auth)

**10453** RELATION OF EMBRYO STRUCTURE, NODE POSITION, TILLERING AND DEPTH OF PLANTING TO THE EFFECTS OF X-RAYS IN BARLEY. Patricia Sarvella, R. A. Nilan, and C. F. Konzak (Mississippi State Univ., State College and Washington State Univ., Pullman). Radiation Botany, 2: 89-108(Nov. 1962). (In English)

Biological, especially genetic, effects of x rays in barley were influenced by embryo development, node position in $M_1$ plants, depth of planting, and plant tillering. Bud or tiller-initial viability was determined with the vital stain, tetrazolium chloride. Both deeply planted and irradiated seeds exhibited reduced tillering from the bud in the axil of the coleoptile. Mutation rates (frequencies of chlorophyll-deficient $M_2$ seedlings) were calculated by the $M_1$ plant, $M_1$ spike, or $M_2$ seedling methods. Mutation rates were also determined by each method for apical spikes, primary and secondary axillary spikes, and each node position. The latter rates differed less from one another when scored by the $M_1$ spike or $M_2$ seedling methods than when scored by the $M_1$ plant method. The $M_1$ spike mutation curve approached closest to linearity for plants with all primary axillary and apical spikes present and with all duplicate mutants excluded. Reliable mutation rates can be calculated from the apical spike alone. Node position on the $M_1$ plants, with the exception of the fourth node, did not appear to affect mutation rates. Spikes above the fourth node and from secondary axillary tillers frequently had as many or more mutations than the primary axillary spikes. In fact, a higher mutation rate occurred in plants with higher numbers of tillers. Summarized mutation rates of the primaries at the upper nodes were higher than at the lower nodes. The converse was true for the secondaries, which also had lower rates than the primaries. Fluctuations in rates were related to variations in embryo structure and to a decrease in the number of nodes (with tillers), spikes, and seedlings per plant. Therefore, the nearly linear mutation rates with increasing dose are probably related to high numbers of tillers, which would permit mutant cells to be detected. (auth)

**10454** CHROMOSOMAL ABERRATION GRADIENTS IN TRADESCANTIA ANTHERS. Alvin V. Beatty, Jeanne W. Beatty, and Betty C. Moore (Emory Univ., Atlanta). Radiation Botany, 2: 109-14(Nov. 1962). (In English)

Inflorescences were x irradiated for one minute at 400 r/min in atmospheres of helium, 100% oxygen, 5% oxygen with 95% helium or 95% CO, and 20% oxygen with 80% helium or 80% CO, fixed 96 hr later in Craf fixative, then sectioned and stained in crystal violet. After the sections were projected and traced, cells in metaphase of the first microspore division were identified, their position in the cross-section of the anther marked, examined subsequently under oil immersion for chromosomal aberrations of the ring and dicentric types and recorded as aberrations occurring in the outer or inner regions of the tissue. Materials irradiated in the various gases gave aberration yields per cell, in outer and inner regions respectively, of: 0.74 and 0.44 in 5% oxygen, 0.85 and 0.61 in 20% oxygen, 0.23 and 0.26 in helium, and 0.96 and 0.86 in 100% oxygen. Material irradiated in the 5% oxygen–helium mixture, then post-treated in CO, gave yields of 0.64 and 0.66, while the same treatment in 20% oxygen–helium mixture gave 0.82 and 0.80. The aberration gradients found were interpreted on a metabolic gradient basis, which would influence recovery, rather than on an oxygen gradient in the tissue during irradiation, which would modify breakage. (auth)

**10455** ABSENCE OF INTERACTION BETWEEN NITROGEN MUSTARD AND VISIBLE RADIATION IN MUTATION INDUCTION IN NEUROSPORA CRASSA. D. T. Klein and R. M. Klein (Albert Einstein Coll. of Medicine, New York and New York Botanical Garden). Radiation Botany, 2: 115-18(Nov. 1962). (In English)

Conidia of the purple-adenineless mutant of Neurospora crassa (38701) were exposed to red or far red light after exposure to nitrogen mustard or far red light preceding treatment with nitrogen mustard. No significant alterations in survival, the induction of mutants expressed by abnormal colony formation, or reversions to adenine prototrophy could be ascribed to the visible radiations. (auth)

**10456** NUCLEIC ACID AND PROTEIN METABOLISM OF BARLEY SEEDLINGS. III. EFFECT OF X-RAYS. L. Ledoux, P. Galand, and R. Huart (Centre d'Etude de l'Energie Nucléaire, Mol, Belgium). Radiation Botany, 2: 119-24(Nov. 1962). (In English)

The effect of 500, 2500, 12500, and 62500 r of x rays on several constituents of germinating barley was studied. Such doses inhibit the increase in RNA, DNA, protein, acid soluble, and soluble N content. The acid RNase activity varied proportionally to the RNA content, except in the coleoptile, where irradiation greatly enhanced the frequency of an abnormal distal region rich in RNase and poor in RNA. The origin of the enzymic activity and the interpretation of the results are discussed in relation to the possibility of interference of translocation mechanisms with the normal synthetic processes. (auth)

**10457** BIOLOGICAL EFFECTS PRODUCED BY X-RAYS AND THERMAL NEUTRONS IN DIPLOID AND HEXAPLOID SPECIES OF AVENA. F. K. S. Koo (Univ. of Minnesota, St. Paul). Radiation Botany, 2: 131-40(Nov. 1962). (In English)

Differential responses of diploid and hexaploid oats to radiation and comparisons of effects produced by x rays and thermal neutrons are reported. The biological effects produced by the two ionizing radiations were measured in terms of the number of plants that survived to maturity and plant height in the first treated generation and the mutation rate and mutant types in the second generation. The number of plants that survived to maturity after irradiation treatment was found to be greater and the mutation rate lower in the hexaploid variety Minhafer than in the diploid variety Saia. These were attributed to the reduplication of genes or chromosomes in the hexaploid. Although the difference was small, the mean reduction in plant height was evidently higher in the hexaploid than in the diploid. This may be attributed to the presence of a proportion of plants with gross chromosomal aberrations that might be responsible for severe plant height reduction in the hexaploid. The better tolerance of the hexaploid to gross chromosomal aberrations was interpreted as due to the reduplication of chromosomes. Though not conclusively, the mutation spectra of the two ploids appeared to be not the same. The proportion for each of the mutant types recovered in one variety was strikingly different from that in the other. In Saia the most frequent mutations were albinos and light greens while in Minhafer the most common types were light greens, bands, and stripes. No apparent difference between the effects of x rays and thermal neutrons on the reduction of plant height was observed. Thermal neutrons appeared to be more effective than x rays in producing mutations in both varieties at the same survival level. It was also found that more albinos in Saia and more bands in Minhafer were induced by thermal neutrons than by x rays. (auth)

**10458** SEPARATE X IRRADIATION OF THE LAMELLAR ELEMENTAL STRUCTURE AND ISOLATED ENZYME EXTRACTS OF CHLOROPLASTS AND THE EFFECT OF THE LIGHT-DEPENDENT TPN REDUCTION. W. Fuechtbauer and W. Simonis (Universität, Würzburg, Ger.). Radiation Botany, 2: 141-56(Nov. 1962). (In German)

Chloroplasts were isolated from spinach leaves, disrupted, and washed in a hypotonic water solution. Suspensions of chloroplast fragments prepared in this manner, and a clear chloroplast extract were x irradiated separately, and the light-dependent reduction of TPN was tested afterwards. The concentration of the chloroplast fragments as well as that of the extract were chosen in such a way, that they limit the TPN-reduction. Therefore, the rate of the reaction is a measure of the x-ray inactivation of both fractions. The addition of irradiated chloroplast fragments to non-treated extract resulted in sigmoid dose-effect curves, whereas irradiation of extract only yielded exponential curves. Reasons for the shape of the curves are discussed. A strong dilution effect appeared not only in the extract but also in the suspension of chloroplast fragments. In both cases a logarithmic plot of the inactivation dose against the concentration gave a straight line, the angles of ascent being lower than 45°. Reasons for this are discussed. A unicellular alga showed no dilution effect. It is discussed in detail, in which cases a dilution effect of suspensions of particles is to be expected. Comparing the inactivation doses of chloroplast fragments and of the extract with regard to the amounts of the two fractions contained in the isolated chloroplasts, it was found that the soluble enzyme in the case of the TPN-reduction was much more sensitive to radiation than the stable lamellar system of the chloroplasts. The radiation effect rose in both fractions with increasing time after irradiation. If irradiated chloroplast fragments and irradiated extract were put together, the result was a stronger inactivation than expected by calculation. An explanation of this effect is given. When the inactivation exceeds 90%, the chloroplasts cluster and the extract precipitates. Both effects are regarded as a consequence of protein coagulation. When chloroplast fragments were irradiated with very high doses, the chlorophyll was destroyed, the inactivation dose of this destruction being nearly 20 times higher than that of the TPN-reduction. (auth)

**10459** THE PHYSIOPATHOLOGICAL PICTURE FROM IRRADIATION OF THE BRAIN IN RATS. S. Greco, G. Pisani, and M. L. Tognacca (Università, Catania, Italy; Instituto di Radiologia dell'Ospedale Maggiore, Novara, Italy; and Università, Messina, Italy). Radiobiol. Latina, 4: 275-96(Oct.-Dec. 1961). (In Italian)

In 1,300 Long-Evans rats, the effects of irradiation of the brain (with 200 kv x rays or $Co^{60}$ gamma rays, in doses of 1500, 3000, 4000, and 5000 rads administered either as a single dose or in daily fractions of 250 rads) were studied with regard to survival, changes in body weight, local reaction in the irradiated zone, and neurological symptoms. While different responses in animals at the same dose of 1500 rads administered in a single exposure were observed, no important difference was found in animals exposed to 200 kv x rays or 1.25 Mev gamma rays from $Co^{60}$ in 250 r fractions or in single doses exceeding 3000 r. (auth)

**10460** MODIFICATIONS OF THE ULTRASTRUCTURE OF PURKINJE CELLS IN ANIMALS EXPOSED TO THE ACTION OF IONIZING RADIATION. R. Bruno (Università, Messina, Italy), F. Finocchio, S. Greco, and G. Pisani. Radiobiol. Latina, 4: 311-42(Oct.-Dec. 1961). (In Italian)

Ultrastructural modifications of cerebellar Purkinje's cells were studied in rats at different times following treatment with ionizing radiations, given in one sitting. A dosage of 1500 rad was found to lead only to neuron modifications. It was concluded that the ultrastructural changes which are found right after irradiation may either regress in the following hours or evolve into degenerative aspects. (auth)

**10461** FIRST RESULTS ON THE ULTRASTRUCTURE MODIFICATIONS OF THE NEURONS OF THE GASSER GANGLION IN RATS FOLLOWING EXPOSURE TO IONIZING RADIATION. S. Greco (Università, Catania, Italy), E. Meriggi, A. Santoro, and C. Viviani. Radiobiol. Latina, 4: 347-70(Oct.-Dec. 1961). (In Italian)

The electron microscope was used to study the ultrastructural modifications of the nerve and glia cells of Gas-

ser's ganglion in rats following ionizing radiations. It was found that neuron alterations are more intense at the end of irradiation and tend to regress during the following hours, whereas there is an intensification of alterations in the satellite cells. It is concluded that neuron alterations in the late stage are most probably secondary to a primitive lesion of glial cells. (auth)

**10462** THE LYMPH OF THE THORACIC DUCT IN RABBITS EXPOSED TO WHOLE-BODY IRRADIATION WITH $Co^{60}$ (BEHAVIOR OF THE CORPUSCLES AND THE PROTEIN). Carlo A. Castelli and Marco Marcato (Università, Parma, Italy). Radiobiol. Latina, 4: 371-80 (Oct.-Dec. 1961). (In Italian)

The behavior of corpuscles and the proteic pattern of the lymph of the thoracic duct were examined in rabbits treated by whole-body irradiation with $Co^{60}$. There existed significant modifications with the different dosages given; generally, they are represented by a diminution both of white globules and of proteins, being proportional to the dosage. (auth)

**10463** EFFECTS OF X IRRADIATION ON THE URINARY EXCRETION OF SODIUM AND POTASSIUM IN TWO DIFFERENT STRAINS OF RATS WATERED WITH SPRING WATER AND WITH ISOTONIC SOLUTIONS OF SACCHAROSE. M. Bindoni, U. Meldolesi, S. Modica, and C. Rapisarda (Università, Catania, Italy). Radiobiol. Radioterap. Fis. Med., (3) 17: 163-73(May-June 1962). (In Italian)

The effects of x irradiation (700 r) on the urine elimination, water consumption, and urinary excretion of sodium and potassium were studied in two different strains of rats. The irradiation causes in the wild grey rat, during the 24 hours following the x-ray treatment, an increase in urine elimination, water consumption, and urinary excretion of sodium and potassium. Such effects do not appear in the albino rat after a similar dose of irradiation (700 r). The administration of 0.25 M saccharose solution, as a drink, immediately after the irradiation (700 r) completely prevents, in the wild grey rat, the increase in urinary elimination of sodium and potassium. (auth)

**10464** THE HEPATIC FUNCTION IN IRRADIATED CANCER PATIENTS. R. Sorrentino, G. Savino, and E. Fumagalli (Ospedale Maggiore, Novara, Italy). Radiobiol. Radioterap. Fis. Med., (3) 17: 174-86(May-June 1962). (In Italian)

Protein, glycine, and liped metabolism were examined in 97 patients with various neoplastic growths not involving the liver. Light signs of hepatic insufficiency were found in 12 of 47 patients who initially had shown normal serous pictures. (D.E.B.)

**10465** EFFECTS OF IONIZING RADIATIONS ON COLLAGENS. III. THE COLLAGEN FRACTION IN ATROPHIC MUSCLES. V. Gallucci (Università, Padua), R. Vecchioni, C. Ruffato, and M. Bottero. Radiobiol. Radioterap. Fis. Med., (3) 17: 187-92(May-June 1962). (In Italian)

The behavior of the collagen fractions of the connective matter of the rat's muscle during the atrophy process was examined by denervation. It was found that irradiation, probably through cellular damage, produces a slower increment of the soluble fractions, the concentration of which, in the irradiated atrophied muscles, is always less with respect to controls; consequently also the insoluble fraction presents a delay in the quantitative increment. (auth)

**10466** QUANTITATIVE HISTOPHOTOMETRIC STUDY OF THE NUCLEIC ACIDS (DNA AND RNA) IN NEURONS OF CEREBELLUM AND GASSER GANGLION OF THE RAT IRRADIATED WITH $Co^{60}$ $\gamma$ RAYS. R. Sorrentino, G. Savino, and M. L. Tognacca (Università, Messina, Italy). Radiobiol. Radioterap. Fis. Med., (3) 17: 193-208(May-June 1962). (In Italian)

Employing a quantitative spectrophotometric method, the early post-irradiation behavior of the nucleic acids (DNA-RNA) in the cells of the granular layer and of the Purkinje (normochromatic cytotypes) of the cerebral cortex as well as in Gasser's ganglion was analyzed in mice that underwent an external teleirradiation with Co-60 gamma rays and collimated bundle on the head region. The animals, treated by doses of 1500 or 3000 rads, were killed at 10 min, 6 hr, 24 hr, and 7 days from the end of the treatment. As regards the DNA, the determinations of the nuclear quantities were carried out taking into consideration the nuclear volumes. A superposition in behavior of both DNA and RNA was noticed both in cerebellum neurons and in Gasser's ganglionic cells. In fact, a decrease was found after 10 min that became more noticeable after 6 hr and appeared reduced after 24 hr and further reduced after 7 days. Such variations were more evident in animals treated with 3000 rads. (auth)

**10467** VARIATIONS IN SURVIVAL TIME AFTER WHOLE-BODY RADIATION AT TWO TIMES OF DAY. Donald J. Pizzarello, Richard L. Witcofski, and E. Ann Lyons (Bowman Gray School of Medicine, Winston-Salem, N. C.). Science, 139: 349(Jan. 25, 1963).

Rats, anesthetized with sodium pentobarbital, given 900 roentgens of x radiation over the entire body, survived more than 130 days when the radiation was given in the morning. The same dosage killed all the animals within 13 days when the radiation was given at night. (auth)

**10468** GLUCOSE, PYRUVIC ACID, AND FORMIC ACID METABOLISM BY BACTERIA AFTER X-RAY IRRADIATION. Helmut Pauly and Boris Rajewsky (Max-Planck-Institut für Biophysik, Frankfurt am Main). Strahlentherapie, 119: 481-5(Dec. 1962). (In German)

Inactivation by x ray of the $O_2$-uptake during glucose- and pyruvic acid-degradation as well as of the $H_2$-development from formic acid was investigated and found dose dependent. The bacterial strains Escherichia coli B and Staphylococcus aureus SG 511 were used. There was significant inhibition only at doses over 1 million roentgens, excepting the part of about 30 to 40% of the glucose-consumption of E. coli B. The radiation sensitivity was reduced by $\frac{1}{3}$ to $\frac{1}{10}$ if the bacteria were irradiated at the temperature of liquid air. (auth)

**10469** INFLUENCE ON THE ACTIVITY OF THE ENZYME PYRUVIC ACID KINASE BY RADIATION-CONDITIONED ELECTROLYTIC DISPLACEMENT. Hans-Dietrich Bergeder and Georg Geissler (Universität, Bonn). Strahlentherapie, 119: 513-24(Dec. 1962). (In German)

Investigations were done with the enzyme pyruvic acid kinase to determine whether the ion-displacement observed in tissues irradiated with high dosages can cause a change of metabolic processes. The activity of the pyruvic acid kinase-solutions was inhibited by x rays depending on the concentration. However, a significant inhibition of the activity of the muscle-pyruvic acid kinase could not be observed after irradiation of isolated frog muscles with doses up to 300 kr. A diminishing of the $K^+$-concentration, which could be observed after irradiation, too, prejudiced the activity of the pyruvic acid kinase as could be shown in in-vitro-experiments without irradiation. During the pyruvic acid kinase-test Boehringer the dependence on $K^+$ was covered mostly by $NH_4$-ions which were introduced into the test solution by lactic acid dehydrogenase, pyruvic acid kinase, and phosphoenol-pyruvic acid. The possibility that $K^+$-loss of cells irradiated with high dosages might be followed by enzymatic reactions, is discussed. (auth)

**10470** CORTISONE AND RADIATION. [PART] IV. Charles C. Berdjis (U. S. Army Medical Unit, Fort Detrick, Md.). Strahlentherapie, 119: 545-56(Dec. 1962). (In English)

A study was undertaken to ascertain the simultaneous effect of cortisone and radiation in rat submaxillary gland. From the earlier reports in mice and the investigation in rats, it is concluded that: there is a striking similarity between submaxillary gland and kidney, both in normal (sexual dimorphism) and in irradiated animals (masculinization); the functional activity of submaxillary gland and kidney is highly disturbed by hormonal imbalance (gonadal disturbances and ovarian atrophy) created by radiation and reinforced by cortisone; these organs are under the influence of endocrine glands; and cortisone reinforces the injurious effects of radiation, resulting in a premature response. Physiological activity, histologic structure, and its variations, and the inter-relationship of submaxillary gland and kidney with the endocrine glands are discussed. (auth)

**10471** INVESTIGATION OF THE EFFECTS OF DIFFERENT RADIATION QUALITIES ON THE EXTREMITIES OF CHICKENS. Gustav Bonse and Werner Bohndorf (Universität, Wurzburg, Ger.). Strahlentherapie, 119: 564-8 (Dec. 1962). (In German)

Of 48 chickens, 24 animals received single tele-$Co^{60}$-radiation doses of 1200, 1400, and 1600 r, a comparative group the same dose under conditions of contact radiation to the tarso-metatarsal joints. The experimental group did not show a significant difference in shortening of the irradiated extremity after radiation with the same doses but with different kinds of rays. The retardation of growth of the $Co^{60}$-treated extremity was slower, but finally reached the same extent. Change of structure of the radiated skeletal parts could hardly be demonstrated with ultrahard rays but was seen to a severe degree after conventional x rays. In the control group treated with $Co^{60}$ similar findings could not be demonstrated. (auth)

**10472** RADIATION PROTECTION WITH THE BUTAZOLIDINE METABOLITE I TANDERIL. PART I: EXPERIMENTAL INVESTIGATION CONCERNING THE PROTECTIVE EFFECTS OF TANDERIL FOR DOSES BEFORE AND AFTER TOTAL-BODY IRRADIATION OF WHITE MICE WITH $Co^{60}$. Herbert Graebner, Walter Kern, and Peter Abramowski (Universität, Nuremburg and Universität, Giessen, Ger.). Strahlentherapie, 119: 615-19 (Dec. 1962). (In German)

The experiments described in 180 female white mice show a significant radiation protection effect of Tanderil after a total body irradiation with $Co^{60}$. The anti-inflammatory and antihistamine qualities of Tanderil are discussed in relation to the protection effect. (auth)

**10473** "KILLING EFFECT" OF INJECTED LYMPH NODE CELLS IN HOMOLOGOUS RADIATION CHIMERAS. O. Vos and W. W. H. Weyzen (National Defense Research Organization T.N.O., Rijswijk, Netherlands). Transplant. Bull., 30: 111-17(Oct. 1962).

The repopulation of lymph nodes and the killing effect of CBA/Rij lymph node cells injected at various times after irradiation were investigated in lethally irradiated C57BL/Rij and (CBA/Rij × C57BL/Rij) $F_1$ mice treated with CBA bone marrow. A correlation was found between the degree of atrophy of the lymph nodes and the number of cells needed to kill the host. During the first days after irradiation, a high degree of atrophy and a small $ED_{50}$ for lymph node cells (50,000 to 200,000) were observed. The repopulation of the lymph nodes increased in parallel with the number of lymph node cells that had to be injected to give a killing effect. This process occurred more rapidly in $F_1$ than in C57BL mice. A competitive repopulation of tolerant lymph node cells originating from the transplanted bone marrow cells and the injected immunologically active lymph node cells was postulated to explain this observation. (auth)

**10474** A SPECIFIC IMMUNOLOGICAL TOLERANCE IN RADIATION CHIMERAS. O. Vos and W. W. H. Weyzen (National Defense Research Organization T.N.O., Rijswijk, Netherlands). Transplant. Bull., 30: 117-23(Oct. 1962).

Repopulation of the bone marrow and lymph nodes with donor-type cells was demonstrated in C57BL/Rij and (CBA/Rij × C57BL/Rij)$F_1$ mice that had been exposed to a lethal dose of total body x irradiation and treated with CBA bone marrow cells. No apparent symptoms of secondary disease were found in those chimeras that survived 100 days after irradiation and bone marrow transplantation. The same sensitivity to a graft-vs-host reaction was found in C57BL and $F_1$ mice and long-term CBA → C57BL and CBA → $F_1$ chimeras, as tested by the killing effect of CBA lymph node cells. Therefore, no alteration in sensitivity to a graft-vs-host reaction occurred in long-term chimeras. CBA lymph node cells derived from long-term chimeras showed the same immunological activity against isoantigens of a third (RF) strain as CBA lymph node cells from normal CBA mice, but no killing effect of chimeric lymph node cells could be demonstrated in irradiated C57BL or (CBA × C57BL)$F_1$ mice. It is concluded that a specific immunological tolerance of the donortype lymphoid cells towards the host's isoantigens occurred in the long-term chimeras studied. (auth)

**10475** THE BIOLOGICAL EFFECTIVENESS OF THERMAL NEUTRONS AND OF THE HEAVY PARTICLES FROM THE $B^{10}(n,\alpha)Li^7$ REACTION FOR THE RABBIT'S EAR AND ITS UTILIZATION FOR NEUTRON CAPTURE THERAPY. Yasokazu Lucas Yamamoto (Brookhaven National Lab., Upton, N. Y.). Yokohama Med. Bull., 12: 4-22(Feb. 1961).

Attempts were made to determine the minimal dose of thermal neutrons and heavy particles from the reaction $B^{10}(n,\alpha)Li^7$ to produce radiodermatitis in the rabbit ear and to investigate the characteristics of skin reactions and their prevention, especially by neutron shielding materials for medical use. The safe skin dose on the rabbit ear was found to be below $10 \times 10^{12}$ n/cm$^2$ with thermal neutron exposure alone and $1.5 \times 10^{12}$ n/cm$^2$ with 35 mg $B^{10}$ per kg body wt. Clinical data show the maximum safe skin dose to be ~$0.5 \times 10^{12}$ n/cm$^2$ with 25 to 50 mg $B^{10}$ per kg body wt. When one of the rabbit's ears was shielded with Li metal to reduce a thermal neutron dose below the safe skin dose ($1.5 \times 10^{12}$/cm$^2$), no irreversible skin reaction was seen, whereas a severe reaction developed in the unshielded ear. The principles of the animal experiments were adapted for prevention of skin complication in neutron capture therapy for human brain tumors. Prior to neutron capture therapy the entire skin and galea were reflected from the area to be exposed, and a sterile, double layered, plastic cap was placed over the wound to avoid contamination. Skin surrounding the exposure was shielded from thermal neutrons by Li metal coated with mineral oil and contained in plastic bags. High neutron doses (over $5 \times 10^{12}$ n/cm$^2$) were given to the tumor area, and a mild skin reaction and temporary depilation occurred in 6 patients treated in this way. The value of relative biological effectiveness is calculated to be 3.9 from thermal neutron exposure alone and to be 1.87 from neutron capture therapy from $B^{10}(n,\alpha)Li^7$ reaction with 35 mg per kg body wt. (P.C.H.)

**10476** SPECIFIC EFFECTS OF IRRADIATION ON THE LUNG. Shields Warren (New England Deaconess Hospital, Boston). p.303-7 of "Some Aspects of Internal Irradiation." Oxford, Pergamon Press, 1962.

Short $Co^{60}$ wires, of known radiation strength, were implanted directly into the lungs of mice and the carcinogenic dose determined by relation of the time interval, strength of source, and distance of tumor from the source. The lowest dose was 90,000 r and the highest dose was 450,000 r $\gamma$ radiation. The shortest induction time for a lung cancer was 66 days. The longest exposure time over which the mice failed to show lung cancer was 315 days. (C.H.)

## Radiation Sickness

**10477** (NP-12251) QUARTERLY PROGRESS REPORT NO. 45 [ON RADIOBIOLOGY]. (Chicago. Univ. Air Force Radiation Lab.). Oct. 15, 1962. Contract AF 41 (657)-252. 115p.

Separate abstracts were prepared on 8 sections of this report on chemical protection against radiation injuries in rats and mice. (C.H.)

**10478** (NP-12251(p.1-11)) INFLUENCE OF X-IRRADIATION ON THE DEVELOPMENT OF A THIOPHOSPHATE-OXIDIZING ENZYME SYSTEM IN THE LIVERS OF RATS. Bernard E. Hietbrink, Susan B. Ketola, and Kenneth P. DuBois (Chicago. Univ. Air Force Radiation Lab.).

Studies were undertaken to determine the duration of the radiation-induced inhibition in the development of the phosphorothioate-oxidizing enzyme system in the livers of young male rats. It was found that the enzyme activity in the livers of rats given 100 r of x ray at 23 days of age reached the normal level at about 30 days after exposure. The enzyme activity of the livers of animals given 200 r at 23 days of age was still substantially lower than control levels during the fifth week following x irradiation. The results of experiments concerning the influence of partial body shielding on the development of the phosphorothioate-oxidizing enzyme system in the liver of young male rats indicated that the administration of 400 r of x irradiation to the liver area did not inhibit the rate of synthesis of the microsome enzymes but appeared to have a mild stimulating effect. The administration of 200 mgm/kgm of MEA ten minutes before the 23-day old male rats were given 200 r of x ray prevented the radiation-induced inhibition in the development of the drug metabolizing enzyme system. Measurements of the effect of 400 r of whole-body x irradiation on the methyltestosterone-induced increase in the activity of the phosphorothioate-oxidizing enzyme system in the livers of adult female rats indicated that this dose of radiation caused a substantial inhibition in the rate of synthesis of this enzyme in the livers of rats given 20 mgm/kgm of this androgen every other day. (auth)

**10479** (NP-12251(p.12-21)) THE INFLUENCE OF X-IRRADIATION ON PYRIDINE NUCLEOTIDE-LINKED DEHYDROGENASES AND GLUCOSE-6-PHOSPHATASE ACTIVITY OF RAT TISSUES. Kenneth P. DuBois, Ann B. Raymund, and B. E. Hietbrink (Chicago. Univ. Air Force Radiation Lab.).

The glucose-6-phosphate dehydrogenase activity of the livers of normal, young rats, varying from 23 to 42 days of age, was measured. It was found that the enzyme activity of the livers of 23-day old rats was about 50% of the adult level but two days later and at all subsequent periods the activity was at the adult level. Exposure of 22-day old male rats to 400 r of whole-body x irradiation delayed the development of the enzyme activity to the normal adult level by a few days. A quantitative assay method for measurement of the glucose-6-phosphatase activity of the livers of young rats was developed and applied to the livers of normal and irradiated, young animals. The method was based upon measurement of the liberation of inorganic phosphors from glucose-6-phosphate incubated with liver homogenates. Comparison of the glucose-6-phosphatase activity of the livers of adult and young rats showed that there is no difference between weanlings and adult animals in the enzyme activity of the liver. However, the activity of the livers of adult females was 29% lower than the activity of adult males. Exposure of adult rats to 800 r of x ray had no effect on the glucose-6-phosphatase activity of the livers. Exposure of 22-day old rats to 400 r caused a 26% increase in activity in three days but this effect was transient since the enzyme activity had returned to normal by five days after irradiation. (auth)

**10480** (NP-12251(p.22-33)) THE INFLUENCE OF VARIOUS CHEMICAL COMPOUNDS ON RADIATION-INDUCED CHANGES IN ENZYME ACTIVITIES IN CERTAIN RAT TISSUES. Bernard E. Hietbrink, Sue B. Ketola, and Ann B. Raymund (Chicago. Univ. Air Force Radiation Lab.).

Studies were undertaken to determine the radioprotective activity of mixtures of various chemical agents for enzyme systems in the spleen, thymus glands, and intestine of rats. Results of these experiments indicated that the oral administration of the mixture of 250 mgm/kgm of AET and 1,000 mgm/kgm of cysteine provided essentially the same degree of protection to the tissues studied as did the intraperitoneal injection of the mixture of 150 mgm/kgm of AET and 1,000 mgm/kgm of cysteine. In general, the addition of pentobarbital to the mixtures failed to increase the radioprotective activity of the compounds studied. The administration of 1,000 mgm/kgm of propylene glycol, 200 mgm/kgm, 300 mgm/kgm or 500 mgm/kgm of ethyl alcohol immediately after 400 r of x ray provided a significant reduction in the biological effect of radiation in the spleen but did not substantially benefit the thymus glands and intestine. Injection of 200 mgm/kgm of ethyl alcohol immediately before or 500 mgm/kgm of this agent ten minutes prior to x ray caused significant reductions in the biological effect of 400 r in the spleen and intestine. The influence of post-irradiation administration of propylene glycol or mixtures of propylene glycol and ethyl alcohol on the radioprotective activity of various sulfur-containing compounds was tested. This treatment provided marked reductions in the biological effect of 400 r in the spleen in all cases. Propylene glycol did not affect the radioprotective activity of MEA in the intestine but the injection of mixtures of propylene glycol and ethyl alcohol to irradiated animals which had been pretreated with MEA, reduced glutathione or cysteine decreased the radioprotective activity of these sulfur-containing agents in the intestine. The administration of 200 mgm/kgm of ethyl alcohol immediately before or after x irradiation did not prevent mortality of rats given 850 r. Batyl alcohol was not capable of preventing the lethal effects of radiation when given immediately after exposure. Mixtures of 500 mgm/kgm of cysteine and 150 mgm/kgm of AET and 1,000 mgm/kgm of cysteine and 100 mgm/kgm of AET did not permit the animals to survive after 1,000 r of x ray. Initial studies indicate that the post-irradiation injection of batyl alcohol to rats which had been pretreated with MEA provides a greater degree of protection against the lethal effects of 1,200 r than MEA administered singly. (auth)

**10481** (NP-12251(p.34-46)) THE INFLUENCE OF VARIOUS CHEMICAL COMPOUNDS ON RADIATION LETHALITY IN MICE. V. Plzak, M. Root, and J. Doull (Chicago. Univ. Air Force Radiation Lab.).

Forth-six compounds were evaluated for radioprotective activity in mice when given immediately prior to an acute lethal x ray exposure. Eight of the compounds included in the present series exhibited protective activity in that they permitted some of the animals to survive for 30 days after a lethal radiation exposure. Nine of the compounds included in the present series were also tested chronically (daily administration for four days prior to the x ray exposure) and protective effects were obtained with four of these hydrazine derivatives. However, the propylene glycol treated controls for these tests also exhibited protective effects so that the possible protective activity of these agents will require verification in additional studies. (auth)

**10482** (NP-12251(p.47-66)) PRELIMINARY STUDIES ON THE MECHANISM OF THE RADIOPROTECTIVE EFFECTS OF CYANIDE AND VARIOUS NITRILES. J. Dilley and J. Doull (Chicago. Univ. Air Force Radiation Lab.).

The radioprotective effects of potassium cyanide were investigated in male and female mice in regard to optimal dose and optimal time of administration in order to provide a basis for further investigation of the mechanisms responsible for the radioprotective effects of cyanide and other cyano-containing derivatives. Maximum radioprotective activity is obtained with dosage levels of potassium cyanide which are slightly less than the lethal dosage levels for this compound. When the dosage level is reduced to less than 2.0 mgm/kgm (as HCN) the protective effect falls off rapidly. The optimal time for administering KCN in order to achieve the greatest radioprotective effect is immediately prior to the x ray exposure. When the interval between the cyanide administration and the radiation exposure is greater than ten minutes, the radioprotective effect is no longer detectable although there is a slight indication of a delayed or secondary protective effect when the agent is given 30 minutes prior to the x ray exposure. Preliminary studies indicate that the dose reduction factor for cyanide will probably be greater than 1.6. High pressure oxygen (60 pounds oxygen) during the radiation exposure reduced the number of cyanide-treated mice surviving for 30 days after 700 r of whole-body x irradiation from 30% to 0%. Acetone cyanohydrin is only slightly less protective than cyanide on a molar basis but the duration of the response appeared to be prolonged over that of cyanide. Acrylonitrile was found to be less effective than cyanide in preventing radiation lethality in male and female mice and partially dependent on the presence of an added inhibitor substance present in commercial samples of this nitrile derivative. (auth)

**10483** (NP-12251(p.67-89)) FURTHER STUDIES ON THE MECHANISM OF THE TOXIC AND RADIOPROTECTIVE EFFECTS OF p-AMINOPROPIOPHENONE AND DERIVATIVES IN MICE. V. Plzak, M. Root, and J. Doull (Chicago. Univ. Air Force Radiation Lab.).

The toxicity, radioprotective effects, and methemoglobin-producing ability of p-aminopropiophenone was investigated in male and female rats and mice. Data are included on the effects of increased tissue oxygenation on the methemoglobinemia of p-aminopropiophenone-treated mice, and a comparison of oxygen consumption, methemoglobinemia, and radioprotective activity of various phenone derivatives in mice. (C.H.)

**10484** (NP-12251(p.90-8)) STUDIES ON THE TOXICITY OF RARE EARTH COMPOUNDS AND THEIR INFLUENCE ON RADIATION LETHALITY. David W. Bruce and Kenneth P. DuBois (Chicago. Univ. Air Force Radiation Lab.).

Studies on the mortality of male and female rats given cerium(III) nitrate intravenously showed that there is a sex difference with respect to the toxicity of this compound. Approximate $LD_{50}$ values of 1.4 mgm/kgm and 16.0 mgm/kgm for the metal were obtained in female and male rats respectively. Intravenous administration of 2 mgm/kgm of praseodymium as the nitrate salt cause a decrease in blood glucose of female rats. The percentage decrease from the control value at 24, 48, and 72 hours averaged 19%, 42%, and 53% respectively. Whole-body x irradiation (500 r) alone caused a 16% decrease in blood glucose in 24 hours and a 29% decrease at the same time interval when 500 r was given in combination with 2 mgm/kgm of praseodymium intravenously. A 31% to 57% increase in the toxicity of intravenously administered praseodymium nitrate (2 mgm/kgm) was observed when given 10 to 15 minutes prior to doses of total-body x irradiation ranging from 50 r to 500 r. (auth)

**10485** (NP-12251(p.99-113)) A COMPARISON OF THE GROSS PATHOLOGIC FINDINGS IN THE BLOOD VESSELS OF RATS AND MICE EXPOSED TO ACUTE AND CHRONIC X-IRRADIATION WHILE RECEIVING VARIOUS ATHEROGENIC AND HIGH FAT DIETS. D. Vesselinovitch, J. Doull, R. W. Wissler, and J. Meskauskas (Chicago. Univ. Air Force Radiation Lab.).

Male rats and mice were fed various atherogenic and high fat diets for a period of 12 weeks following the administration of acute x ray doses of 400 r to 600 r and during the administration of chronic x irradiation at a dose rate of either 20 r or 40 r per day (five days per week) in an effort to obtain information concerning the role of blood vessel injury in the pathogenesis of acute and chronic radiation injury. The body weight and the weight of most of the organs was decreased in both rats and mice fed atherogenic diets or a high fat diet when compared to that of animals fed a control diet. Chronic radiation exposure at a dose rate of 20 r per day did not produce marked changes in the body weight of rats or mice fed the control diet or in animals fed the various atherogenic and high fat diets. When the chronic x ray dose was increased to 40 r per day, the body weight of the animals fed the control diet was decreased by 25% to 50%. The decrease in body weight of the rats and mice fed the various atherogenic and high fat diets while receiving this dose of chronic x irradiation was only slightly greater than the change resulting from the feeding of the diets alone and with some of the diets the changes were less marked than those resulting from feeding the diets to non-irradiated animals. All of the atherogenic and high fat diets used in these studies caused a decrease in the liver weight of non-irradiated mice but not in non-irradiated rats. The combination of these diets with chronic x ray exposure did not produce marked changes in the liver weight when compared to the effects of the diet alone. The spleen weight of both rats and mice was decreased by the feeding of the various atherogenic diets and the addition of chronic radiation exposure did not enhance these effects in mice although the rats fed the Wilgram and Fillios diets exhibited a greater weight loss than rats fed the control diet. Both the radiation exposure levels used for these studies caused a marked decrease in the testis weight of mice and rats fed the control diet. Similar weight losses were seen in the mice fed the Wissler, Wilgram and Nursing Chow diets and in the rats fed the Wilgram, Fillios and Thomas-Hartroft diets. The intensity, incidence and area involved following staining of the aorta with Sudan IV was estimated in the control and chronically x irradiated rats

fed the various diets employed for these studies. Marked sudanophilia (¼ to ½ of the total surface area involved) was observed in almost all of the non-irradiated rats fed the atherogenic diets whereas less than half of the rats fed the control synthetic high fat diet were affected. Exposure of the animals to chronic radiation at either 20 r or 40 r per day reduced the sudanophilia and this was most pronounced in the rats fed the Wilgram and Fillios diets. The chronic radiation exposure did not decrease the sudanophilia seen in the rats fed the control diet or the high fat diet. (auth)

**10486** (TID-15931) EFFECTS OF X-IRRADIATION ON THYMIDINE INCORPORATION IN MICE TREATED WITH S, β-AMINOETHYLISOTHIURONIUM BROMIDE (AET). Jiří Fiala (George Washington Univ., Washington, D. C. School of Medicine). [1961]. Contract AT(30-1)-1107. 23p. (NYO-10357)

The effect of the radioprotective agent AET on incorporation of labeled thymidine was studied in small intestine, spleen, and thymus of adult mice exposed to 500 r of whole-body x irradiation. Variations of specific activity of DNA show the protective effect of AET as early as the 8th hour post-irradiation in the intestine and 16th hour post-irradiation in the spleen. There is a significant increase of total labeling in the small intestine and in spleen in the irradiated animals protected by AET, as compared with unprotected mice. The data suggest that the recovery in the small intestine is real both in protected and unprotected animals. In spleen, increase in the specific activity of DNA early after irradiation is probably due to the progressive loss of metabolically inactive DNA. The differences in the specific activities appear much earlier than the differences in the amount of DNA-P in protected and unprotected mice. The protective effect of AET on the labeling of thymus DNA is both decreased and delayed, as compared to that of the small intestine and spleen. (auth)

**10487** NEW INVESTIGATIONS ON PROTECTION BY CYSTAMINE OF THYMOCYTES IRRADIATED IN VITRO. E. H. Betz and G. Booz (Université, Liège). Compt. Rend. Soc. Biol., 156: 1199-1201(1962). (In French)

If thymic cells are placed in contact with cystamine for twenty minutes and then removed immediately before or after irradiation, the protection phenomenon continues to be in evidence. On the contrary, the addition of cystamine to the medium immediately after irradiation does not modify the appearance of cellular radiolesions. These data argue in favor of a true radioprotective effect under the influence of cystamine. (tr-auth)

**10488** SURVIVAL OF RATS IRRADIATED AT VARIOUS TIMES AFTER INJECTION OF CYSTEAMINE. V. Smoliar (Université Liège). Compt. Rend. Soc. Biol., 156: 1202-4 (1962). (In French)

A study was made to determine if the radioprotective action of cysteamine is greatest at the moment when its tissue and cellular rate is decreasing. The results show that there is no correlation between the quantity of cysteamine present in the tissue and the degree of protection that it exercises against a whole-body lethal irradiation. In effect the protective effect still remains high when the tissue concentration of cysteamine is sharply reduced. The maximum protection is shown only after a certain time. (tr-auth)

**10489** IRRADIATION SYNDROME CONTROLLED WITH MECLIZINE AND PYRIDOXINE IN COMBINATION. David M. Sklaroff and Nicholas Karayannis (Albert Einstein Medical Center, Philadelphia). Current Therap. Res., 4: 324-6 (June 1962).

Alleviation of nausea and vomiting, as a result of therapeutic irradiation of malignancies, was attempted in 100 patients. All patients were treated with $Co^{60}$ radiation at a 200-r dose each day. One tablet of meclizine-pyridoxine was given orally 3 times per day throughout the course of radiation treatment. Satisfactory antiemetic results (excellent, good, or fair response) were obtained in 92% of the patients; poor results occurred in only 8 of the 100 patients. An injectable preparation also gave prompt relief of nausea and vomiting in all 10 cases in which it was tried. Little or no local reaction occurred at the site of injection. There was no evidence that the injected substance adversely affected respiration, blood pressure, or pulse. No drowsiness or any other side effect was encountered. Hence meclizine-pyridoxine may be very helpful in the management of irradiated cancer patients. (P.C.H.)

**10490** PADUTINE TREATMENT OF RADIONECROSES-FURTHER ENCOURAGING RESULTS. Euratom Bull., No. 4, 32(1962). (In English)

The cure of a case of acute radiodermatitis of the hand of a workman, by means of "Padutine-Dépôt" pancreas-extract injections, is described. (T.F.H.)

**10491** PROTECTION OF TISSUE-CULTURE CELLS AGAINST IONIZING RADIATION. I. THE EFFECT OF BIOLOGICAL AMINES, DISULPHIDE COMPOUNDS AND THIOLS. O. Vos, L. Budke, and A. J. Vergroesen (Toegepast Natuurwetenschappelijk Onderzoek, Rijswijk, Netherlands). Intern. J. Radiation Biol., 5: 543-57(Oct. 1962).

The radioprotective activity of a number of biological amines, disulfide compounds and thiols at various concentrations was tested in an in vitro system, based on the cloning technique devised by Puck et al. It was found that none of the biological amines (histamine, adrenaline, noradrenaline, and serotonin) or disulfide compounds (cystamine and cystine) showed a protective activity. A definitive protection on the other hand was observed with the thiol compounds (cysteamine, cysteine, and AET). The protective activity of the latter compounds depended on the concentration which was used. Concentrations of 2 to 4 mm gave dose-reduction factors (DRF) between 1 and 2. At higher concentrations (cysteamine 32 mm and cysteine 128 mm) DRF's approaching 4 were obtained. The best protection with AET was observed at a concentration of 128 mm (DRF 2.2). The protection by AET was meliorated if higher serum concentrations in the culture medium were used. The best protection on a mm basis was provided by cysteamine. None of the compounds protected when applied after irradiation. (auth)

**10492** CYSTEAMINE PROTECTION OF GRASSHOPPER CHROMOSOMES FROM X-RAY-INDUCED ABERRATIONS UNDER AEROBIC AND ANAEROBIC CONDITIONS. S. P. Ray-Chaudhuri, J. P. Chaudhuri, and S. Chatterjee (Banaras Hindu Univ., Varanasi, India). Intern. J. Radiation Biol., 5: 591-5(Oct. 1962).

The effect of cysteamine pre-treatment on the frequency of x-ray-induced chromosome aberrations was determined under both aerobic and anaerobic conditions by counting the dicentric bridges in the first division meiotic anaphase of the grasshopper, Gesonula punctifrons. Under aerobic conditions in the cysteamine-treated animals 20.73% bridges were scored as compared with 30 to 90% in the controls. Under anaerobic conditions the scores were 5.35% and 8.22% in the treated and controls, respectively. Thus the degree of protection by cysteamine under both aerobic and anaerobic conditions was found to be more or less the same. The possible mode of protection is discussed. (auth)

**10493** PROTECTION OF TISSUE-CULTURE CELLS AGAINST IONIZING RADIATION. II. THE ACTIVITY OF

HYPOXIA, DIMETHYL SULPHOXIDE, DIMETHYL SULPHONE, GLYCEROL AND CYSTEAMINE AT ROOM TEMPERATURE AND AT −196°C. O. Vos and M. C. A. C. Kaalen (Toegepast Natuurwetenschappelijk Onderzoek, Rijswijk, Netherlands). Intern. J. Radiation Biol., 5: 609-21(Oct. 1962).

Protection against x irradiation by hypoxia, glycerol, dimethyl sulfoxide, dimethyl sulfone, cysteamine, and a combination of glycerol and cysteamine was investigated at +20°C and −196°C. The protective power of the treatment was assayed as the degree to which it prevented radiation damage, i.e., the loss of the reproductive integrity of tissue-culture cells. Using cells attached to a Melinex sheet the following dose-reduction factors (DRF) were found: 15 volume per cent glycerol, 1.9; 15 per cent glycerol + 4 mm cysteamine, 2.8; 0.5, 1, 2, 4, 6, 8, 15, and 30 volume per cent dimethyl sulfoxide, 1.13, 1.3, 1.36, 1.65, 1.58, 1.98, 2.3, and 2.4 respectively; 4 mm cysteamine, 1.9 and anoxia, 2.6. Dimethyl sulfone did not protect against irradiation. Cells in suspension were protected against freezing and thawing by glycerol and dimethyl sulfoxide. Dimethyl sulfone showed no protective activity. Freezing to a temperature of −196°C made cells in suspension less sensitive to x irradiation (DRF 1.9 to 2.8). In these conditions 15 volume per cent glycerol, 1 and 4 volume per cent dimethyl sulfoxide and a combination of 15 per cent glycerol and 4 mm cysteamine gave the same DRF at room temperature and at −196°C (if survival was compared with controls irradiated at the same temperature). However, if for hypoxia similar calculations were made, a much better protection was found at room temperature than at −196°C (DRF 2.2 and 1.1). (auth)

**10494** TREATMENT OF INJURY FROM RADIOACTIVE CONTAMINATION OF THE SKIN AND SUBCUTANEOUS AREAS. Harry Foreman (Los Alamos Scientific Lab., N. Mex.). J. Occupational Med., 4: 426-30(Aug. 8, 1962). (LADC-4814, TID-12268)

The pathology and treatment of skin lesions induced by exposure to $\beta$ or $\alpha$-emitting radioisotopes are reviewed. Data are tabulated on the tissue penetration of common $\beta$-emitting isotopes and the surface dose required to produce recognizable epidermal injury in swine. (C.H.)

**10495** PROLIFERATION AND MATURATION OF MYELOID CELLS IN ACUTE RADIATION SICKNESS. G. I. Kozinets and G. P. Tsessarskaya (Central Inst. of Hematology and Blood Transfusion, USSR). Med. Radiol., 7: No. 12, 43-9(Dec. 1962). (In Russian)

By means of radioactive indicators, features peculiar to proliferative processes in the bone marrow during acute radiation sickness in dogs, monkeys, rabbits, guinea pigs, and mice were studied. Intracellular synthetic processes became disturbed during the first hours after irradiation. Restoration of the cellular composition of the bone marrow occurred earlier than the normalization of intracellular syntheses; 5 to 6 months after irradiation in normal and hematological indexes the inclusion of radioactive precursors was still diminished. (auth)

**10496** SHOCK AND ANURIA AFTER RADIUM AND ROENTGEN IRRADIATION OF UTERINE MYOMATOSUS. F. Kubli and W. Scheitlin (Frauenklinik, St. Gallen, Switzerland). Schweiz. Med. Wochschr., 91: 890-2(July 29, 1961). (In German)

Shock and anuria occurred in a 38-yr-old patient with cervical carcinoma and uterine fibroids who received Ra implantation repeatedly (6000 mg-hr) and abdominal x irradiation (total of 7600 r). Shock developed 1 day after the last Ra implantation and was followed by anuria, icterus, and thrombopenia. The oliguric phase lasted 11 days and the required treatment included extracorporeal dialysis. Renal function was eventually restored to normal. Since liver function was normal, the icteric phase was probably the result of hemolysis. It is suggested that the radioinduced necrosis in the uterus resulted in infection by gram-negative bacteria from which endotoxins were released causing a reaction of the generalized Schwartzman type. (H.H.D.)

**10497** CONCERNING THE IMPORTANCE OF HOLE SIZE FOR SIEVE IRRADIATION FOR THE GENERAL REACTIONS. Werner Dietz and Joachim Starckjohann (Universität, Freiburg i. B. and Rontgeninstitut, Freiburg i. B.). Strahlentherapie, 119: 620-37(Dec. 1962). (In German)

Two groups each of white rats were irradiated with lethal doses (1100, 1000, 900, and 800 r), LD 50/30 d (700 r) and sublethal doses (400 and 100 r) using sieves with hole-diameters of 10- and 5-mm. The general reactions, survival times, survival rates, the behavior of the absolute leucocytes counts and of the leucocytic resistance value, and the behavior of the bone marrow (histologically) were investigated. The reactions of the animals irradiated with sieves containing holes with diameters of 10 mm agreed in all essential points with the reactions of the animals irradiated with sieves containing holes with diameters of 5 mm. The results obtained with these two different hole-diameters agree with the opinion of Seidel, that the general reactions after irradiation using those sieves depend only upon the dose and not upon the hole-diameter. (auth)

# CHEMISTRY

## General and Miscellaneous

**10498** (AAEC/TM-161) THE AQUEOUS COORDINATION CHEMISTRY OF BERYLLIUM AND ITS RELATION TO FUEL PROCESSING. A Literature Survey. J. Aggett (Australia. Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). Nov. 1962. 26p.

A survey of the aqueous coordination chemistry of beryllium is given. The possible use of coordination chemistry in the separation of beryllium from fission products is discussed, and methods for separation processes are outlined. (auth)

**10499** (HW-SA-2595) pH CONTROL BY ION EXCHANGE IN HIGH pH SYSTEMS. Thomas F. Demmitt (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 7, 1962. Contract AT(45-1)-1350. 14p.

The control of pH in high pH aqueous systems by chemical injection and mixed ion exchange is described and the disadvantages of these two methods outlined. Tests were carried out on a weakly acidic carboxylic acid type cation exchange resin as a means of pH control. The results indicate that the lithium form of the resin should yield the highest effluent pH for any given influent solution, and that the pH control capabilities of the resin is dependent on the influent water quality. The resin was found to be more efficient from the pH control standpoint than a strongly acidic resin, and it was put into service in several loops at Hanford. (D.L.C.)

**10500** (IS-385) THE REACTIONS OF SOME NIOBIUM(V) HALIDES WITH PYRIDINE. R. E. McCarley, B. G. Hughes, J. C. Boatman, and B. A. Torp (Ames Lab., Ames, Iowa). [Nov. 9, 1961]. Contract [W-7405-eng-82]. 37p.

The reaction of pyridine and niobium(V) bromide was found to proceed by oxidation-reduction to yield a derivative of niobium(IV), $NbBr_4(C_5H_5N)_2$. This product was identical to that given by the reaction of pyridine and niobium(IV) bromide at room temperature. The oxidation of pyridine by niobium(V) bromide led to the production of 1-(4-pyridyl)pyridinium bromide (I) and pyridinium bromide. Identification of I was accomplished by comparison of the ultraviolet spectra in acidic and basic solutions with those of known salts of I. Niobium(V) chloride also was reduced by pyridine in a manner similar to the reduction of the bromide, but a different reaction stoichiometry was obtained. Tantalum(V) chloride and bromide were not reduced in pyridine but afforded the adducts $TaCl_5(C_5H_5N)$ and $TaBr_5(C_5H_5N)$. In contrast to the mode of the reduction of $NbBr_5$ and $NbCl_5$, both $NbI_5$ and $TaI_5$ appeared to undergo dissociation in pyridine with liberation of iodine according to $2MI_5 + 5C_5H_5N \rightarrow 2MI_4(C_5H_5N)_2 + C_5H_5N \cdot I_2$. The compound $NbI_4(C_5H_5N)_2$ was prepared also by the reaction of $NbI_4$ and pyridine. (auth)

**10501** (IS-458) FORMATION CONSTANTS OF THE COMPLEX SPECIES FORMED BY INTERACTION OF RARE-EARTH NITRILOTRIACETATE COMPLEXES WITH AN EQUIVALENT AMOUNT OF BASE. Asim K. Gupta and Jack E. Powell (Ames Lab., Ames, Iowa). [Apr. 13, 1962]. Contract [W-7405-eng-82]. 11p.

The formation constants of the $RChOH^-$ species, formed by interaction of individual rare-earth nitrilotriacetate species and KOH at 25°C and an ionic strength of 0.1 were determined by the potentiometric method, i.e., computed from the pH values of equilibrium mixtures containing varying proportions of rare-earth complex and base. The relations of these constants to the ion-exchange separation of rare earths at high pH were discussed. (auth)

**10502** (IS-542) GROWTH OF SINGLE CRYSTALS OF LEAD, CADMIUM AND BISMUTH USING THE BRIDGMAN METHOD. James Herriott, Morton Smutz, and Edwin H. Olson (Ames Lab., Ames, Iowa). Nov. 1962. Contract W-7405-eng-82. 25p.

The Bridgman technique was used to grow single crystals of lead, cadmium, and bismuth about ½ in. in diameter and 3 in. long. Rigid quartz or graphite molds were found to be satisfactory for growing single crystals of lead and cadmium, but a "soft mold" was needed in order to grow single crystals of bismuth. Lowering speeds of approximately ⅛ in. per hr were used in the bismuth runs. Lowering speeds of 2 in. per hr could be used with cadmium and 3 in. per hr with lead. Two techniques are described for coping with the tendency of bismuth to supercool which results in rapid crystal growth after nucleation. (auth)

**10503** (NP-12359) EFFECTIVENESS OF SHEARING STRESSES IN ACCELERATING SOLID PHASE REACTIONS AT LOW TEMPERATURES AND HIGH PRESSURES. Technical Report No. 12. Frank Dachille and Rustum Roy (Pennsylvania State Univ., University Park. Coll. of Mineral Industries). Aug. 3, 1962. Contract Nonr-656(20). 16p.

The use of displacive shearing stresses in the study of phase equilibria in opposed anvil high-pressure apparatus was of value in resolving the relations of the anomalous polymorphic thorite-huttonite phases of $ThSiO_4$ and in achieving the first reversibility of the high-low temperature forms of $Nb_2O_5$. Such stresses do not alter noticeably equilibrium, as shown previously by the examples of the calcite-aragonite and quartz-coesite transitions, among others, but do contribute to increasing reaction rates at low temperatures. This is further illustrated in a kinetic study of the $PbO_2$ I-II transition at 40 kb from 25 to 400°C. (auth)

**10504** (NYO-9696) SURVEY OF NON-AQUEOUS CONDUCTANCE DATA. Technical Report No. 8. George J. Janz, F. J. Kelly, and H. V. Venkatasetty (Rensselaer Polytechnic Inst., Troy, N. Y.). Dec. 1962. Contract AT(30-1)-1999. 54p.

A compilation made as part of a research program dealing with the thermodynamics and electrical conductance of inorganic electrolytes in polar organic solvents is presented. Conductance and association constant data are included dating from 1922 through June 1962, classified both by solute and solvent. Other features include a selection of the physical properties of the most commonly-used organic solvents, a guide to alkylammonium salts studied in four or more solvents, and a survey of conductance extrapolation techniques. (auth)

**10505** (ORNL-3320) CHEMISTRY DIVISION ANNUAL PROGRESS REPORT FOR PERIOD ENDING JUNE 20, 1962. (Oak Ridge National Lab., Tenn.). Dec. 11, 1962. Contract W-7405-eng-26. 149p.

A total of nine sections are included in the report. Separate abstracts were prepared for each section. (J.R.D.)

**10506** (ORNL-3320(p.1-15)) NUCLEAR CHEMISTRY. (Oak Ridge National Lab., Tenn.).

Values of 920 ± 90 and 48 ± 5 barns were measured for the resonance integral and (mean) thermal cross section of $Pa^{233}$, with a Cd-filter technique. On the assumption that $Pa^{233}$ obeys the $1/v$ law for Cd-absorbable neutrons, a 2200-m/sec cross section of 46 ± 5 barns was obtained. A comparison of measurements made with Cd and Gd filters indicated that no large resonances exist in the thermal-to-cutoff energy ranges. With Cd-filter techniques and irradiating samples of Bi containing $Bi^{210}$, the thermal cross section and resonance integral to form the 2.16-min $Bi^{211}$ (AcC) were found to be 0.054 and 0.20 barn respectively. Effective energy cutoffs were calculated on an IBM 7090 computer for Cd, Gd, Sa, and B filters as functions of the ratio of Maxwellian to epithermal (assumed to be 1/E) flux, the lower energy limit of the 1/E flux, the energy corresponding to the Maxwellian most probable (modal) velocity, the filter thickness, and the height/diameter ratio (of cylindrical filters). The filters were spherical (which on the assumptions made is equivalent to a beam flux case), cylindrical, and slab. By the use of two or three different filters (Cd and Gd and perhaps Sa), it should be possible to detect resonances in the thermal-to-cutoff energy regions, in addition to measuring resonance integrals and thermal cross sections of unknown nuclides. The calculated cutoff varied by at most 2% as the lower limit of the 1/E flux was varied between 3 and 6 times the Maxwellian temperature. Values of 97 ± 10 and 255 ± 25 barns were found for the activation thermal cross section and resonance integral of $Sm^{150}$ respectively. These values are of interest because $Sm^{150}$ is the nuclide of lowest cross section in the sequence starting with $Pm^{147}$; this sequence, via successive neutron capture, results in $Gd^{156}$. $Sa^{150}$ can effectively interrupt the chain of neutron losses at mass 150 in a high-flux reactor. By measuring the specific activity of the 2.615-Mev gamma ray in a reactor-irradiated and calutron-enriched sample of Bi and by measuring the $Bi^{208}$ content mass-spectrographically, a half-life of $(5.61 \pm 0.15) \times 10^5$ years was found for $Bi^{208}$. By irradiating samples of pure $Ce^{140}$ with neutrons and measuring, with both mass spectrograph and neutron activation analyses, the $Ce^{142}$ produced as the result of double neutron capture, a value of 30 ± 3 barns was obtained for the effective neutron cross section of $Ce^{141}$ in a reactor with a ratio of thermal flux to resonance flux of 12.4. Values of 0.59 and 0.48 barn, respectively, were obtained for the thermal-neutron cross section and resonance integral of $Ce^{140}$. The beta and gamma radiations of 2.7-hr $Pm^{150}$ were investigated by using single- and multicrystal scintillation spectrometers. A decay scheme is proposed which involves excited states in $Sm^{150}$ at 0.333, 0.743, 1.18, 1.66, 1.96, 2.07, 2.41, and 3.08 Mev, together with tentative assignments at 1.77, 1.90, 2.86, and 2.91 Mev. A study of the decay properties of $Cs^{132}$ disclosed energy levels in $Xe^{132}$ at 669, 1300, 1808, and 1988 kev and levels in $Ba^{132}$ at 464 and 1034 kev. From angular correlation measurements, spins are assigned for all of these states. A comparison of these levels with those predicted by various nuclear models is made. Recent experiments extended the information on fission-product yields and half-lives in the mass-99 decay chain; in particular, the existence of a new isomer of $Nb^{99}$ ($T_{1/2}$ = 10 sec) was established. A comprehensive literature survey and evaluation of $U^{233}$ fission-yield data led to the selection of a set of preferred fission-product yield values for the thermal-neutron-induced fission of $U^{233}$. The level structures of $Ge^{71}$, $Ge^{73}$, $Ge^{75}$ and $Ge^{77}$ were studied with the (d,p) reaction. The energy spectra of proton groups leading to excited levels up to approximately 1 Mev were obtained through the use of a Si surface-barrier detector. The Q values corresponding to newly observed levels were determined. Some of the properties of Li-drifted Si diodes were studied. Measurements with these diodes were used in an investigation of the $Ce^{135}$ decay scheme. (auth)

**10507** (ORNL-3320(p.16-21)) ISOLATION AND CHEMICAL PROPERTIES OF SYNTHETIC ELEMENTS. (Oak Ridge National Lab., Tenn.).

A description is presented of a spectrophotometric study of several Re species which may be prepared from Re(V) and Re(VI) in 18M $H_2SO_4$. Data and information are included on hexavalent bromide and chloride complexes and acid strength determinations for hexachlororhenic acid ($H_2ReCl_6$). (J.R.D.)

**10508** (ORNL-3320(p.22-9)) CHEMICAL SEPARATION OF ISOTOPES. (Oak Ridge National Lab., Tenn.).

Selectivities and diffusion coefficients were determined for the exchange of selected alkali-metal ions between cation exchange resins and nonaqueous salt solutions. It was found that the use of Amberlite 200 enables relatively rapid exchange in nonaqueous systems. Generally, the diffusion coefficients in experiments using $Ce^{134}$ tracer were smaller and the selectivities higher in the nonaqueous systems than in aqueous systems. Data are included on ion exchange diffusion and selectivity coefficients in amides and ethylenediamine and the effects of water on these coefficients. In other work, the systematic study of $BF_3$-organic complexes was continued along with $N_2$ exchange, isotopic fractionation between $CO_2$ and carbamic acid, study of $BF_3$ addition compounds, and spectroscopic investigations of isotopic molecules. (J.R.D.)

**10509** (ORNL-3320(p.30-46)) RADIATION CHEMISTRY. (Oak Ridge National Lab., Tenn.).

In the electron bombardment studies of mixtures of ($C_2N_2$ + $H_2$) and ($C_2H_2$ + $N_2$), a common ion mass 27 was shown by appearance-potential techniques to be $HCN^+$ and not $C_2H_3^+$. Other common masses were not identified as to specific ions. This study of the ($C_2H_2$ + $N_2$) mixture is in agreement with early alpha radiolysis studies of the same mixture in that only small amounts (not more than 10%) of nitrogenated products are produced. The gaseous and liquid products resulting from the alpha radiolysis of ethylene were analyzed. The results show that hydrocarbons with an even number of C atoms predominate and that the straight-chain hydrocarbons predominate over the branched compounds. Infrared spectra show the major unsaturated products to be RCH = CHR'. Molecular weight and I number determinations on the liquid polymer show an average of 16 carbons per molecule and one double bond per 10 carbons. The catalytic activity and activation energy of Ge for $H_2$-$D_2$ exchange and its catalytic activity for formic acid dehydrogenation varied significantly with the Fermi level as the latter was altered by doping with n- and p-type impurities. Colors produced on irradiation of certain polynuclear aromatic compounds adsorbed on silica gel were used as evidence for ionic intermediates in the radiolysis. Further experiments on the enhancement by radiation of the $H_2$-$D_2$ exchange activity of silica gel make it even less likely that the mechanism is the removal of a poison by radiolysis. The photolysis of $H_2O_2$ was studied in the presence of dissolved $H_2$ and $O_2$. The ratio of rate constants, $k_{H_2+OH}/k_{H_2O_2+OH}$ = 0.93, is the same as that previously reported for the radiolysis of water. This indicates that the hydroxyl radical produced in the radiolysis of water has the same chemical structure as OH produced by the photodecomposition of $H_2O_2$. Presumably, the $H_2O^+$ initially produced in the radiolysis of water is

rapidly converted to OH. This ratio is insensitive to $H_2$ ion concentration. However, $HSO_4^-$ and $OH^-$ react with OH to form, presumably, $HSO_4$ and $O^-$, respectively. The ratios of rate constants $k_{H_2+OH}/k_{HSO_4^-+OH}/k_{OH^-+OH} = 1.0/0.005/8.0$. The ratio of rate constants $k_{H+H_2O_2}/k_{H+O_2} = 2.2 \times 10^{-3}$, where the H atom is that produced by reaction of $H_2$ with the OH from the photodecomposition of $H_2O_2$. The corresponding ratio for reaction with the H atom produced in the radiolysis of water is 0.6. This and other evidence indicate that the H atom produced by reaction of $H_2$ with OH is a true-H atom, and that the "hydrogen atom" produced in the radiolysis of water is some form of hydrated electron. An important parameter in the diffusion-kinetics model of water radiolysis is linear energy transfer, LET. Yields were measured for the oxidation of ferrous sulfate and for the reduction of ceric sulfate both with and without added thallous ion, by protons of various energies in the range 11 to 23 Mev. From these measurements, derived yields of intermediates $G_H$, $G_{OH}$, $G_{H_2}$, $G_{H_2O_2}$, and $G_{-H_2O}$ were evaluated. The measurements extend the range previously covered (to 10 Mev at Argonne and Brookhaven National Laboratories) into the lower LET range. Methods were devised for accurately measuring both the proton energy and the proton beam current. The $Co^{60}$ gamma irradiation of aqueous $H_2SO_4$ solutions produces the free radicals, H, OH, $HSO_4$, and $HSO_3$ and the molecular products $H_2$, $H_2O_2$, $H_2S_2O_8$, $H_2SO_5$, and $SO_2$. The 100-ev yield of each of these intermediates as a function of $H_2SO_4$ concentration is presented graphically. The H atom reacts with both O molecules and $H_3O^+$ ions. The ratio of rate constants $k_{(H+O_2)}/k_{(H+H_3O^+)}$ was calculated from the ferrous-sulfuric acid system to be 700,000 (±6%). When $Ce^{4+}$ – 0.8 N $H_2SO_4$–$NaNO_3$ solutions are irradiated with $Co^{60}$ gamma rays, the $G(Ce^{3+})$ increases with increasing $NaNO_3$ concentration. Mass spectrographic analyses of molecular $O_2$ in the $H_2O^{18}$-$NaNO_3$ system are correlated with the ionic spectrophotometric analyses of $Ce^{4+}$ in the $Ce^{4+}$–0.8 N $H_2SO_4$–$NaNO_3$ system to explain the enhanced $G(Ce^{3+})$. The measured $G(Ce^{3+})$ is deduced to be a composite of the $G(Ce^{3+})$ measured in the absence of $NaNO_3$, the stoichiometrically equivalent $G(Ce^{3+})$ resulting from the suppression of $G(H_2)$, a direct-action effect on nitrate ion which is directly proportional to nitrate ion concentration, and a possible scavenging reaction of nitrate ion. The investigation of radiolysis by transferred energy was continued with a study of the decomposition of nitrite ions dispersed in K bromide. It was found that the nitrite ion is so distributed in the matrix as to decompose simultaneously by two first-order processes. The initial rates of both processes vary in a regular manner with the initial concentration of nitrite ion. This is qualitatively explained by considering each unirradiated mixture of potassium nitrite and potassium bromide to have a different structure varying regularly with concentration. Discontinuities were found in turbidity-concentration curves measured on pressed disks of dispersions of large ions in potassium bromide. It is believed that this behavior may be compared with that of "colloidal electrolytes" in liquid solutions. By means of low-temperature cells and absorption spectrophotometry, the formation of $O_3$ in liquid $O_2$ and $O_2$-$N_2$ mixtures was observed in situ at 77°K by alternate gamma irradiation and ultraviolet absorption measurement. Extensive energy transfer and enhanced $O_3$ yields were found in the $O_2$-$N_2$ system. In a solution only 0.050% $O_2$, the yield of $O_3$ is equal to 32% of that from pure $O_2$. In pure $O_2$ at 77°K, $G(O_3) = 12.5$ molecules/100 ev. The two Co sources of the Radiation Chemistry Group were reloaded with 2900 and 280 curies; the maximum dose rates are about $2 \times 10^{18}$ and $2 \times 10^{17}$ ev $g^{-1}$ $min^{-1}$ respectively. The Co is distributed to provide a uniform dose rate (within ±2%) over a 3-in. length along the vertical axis. Measurements of the decompositions of the alkali-metal bromates by nuclear reactor radiations as a function of exposure dose at ambient temperatures showed that the gross radiolytic stability sequence was the same as that observed previously with $Co^{60}$ gamma rays. In some instances, however, the relative stabilities differed, and these differences could be attributed to the production of internal radiation sources by thermal-neutron capture in the alkali-metal cation or by the formation of high-LET recoil fragments, as in the fission of $Li^6$. The separate decompositions by thermal neutrons, fast neutrons, and reactor gamma rays were estimated from experiments performed in a thermal column, with thick Li or metal shielding, and with thick Bi metal shielding, respectively. Evidence was obtained for the stepwise radiolytic decomposition of the $BrO_3^-$ ion. (auth)

**10510** (ORNL-3320(p.47-55)) ORGANIC CHEMISTRY. (Oak Ridge National Lab., Tenn.).

Information and data are presented in investigations of $C^{14}$ and deuterium isotope effects, deamination reactions of erythro-2-amino-1-phenyl propanol, deamination reactions in the rearrangement of exo-norbornyl amine, the syn- and anti-isomers of iso-butyrophenone-2, 4-dinitrophenylhydrazone, reactions of TBP with sodium nitrate, and organic thiophosphorus compounds as ligands. (J.R.D.)

**10511** (ORNL-3320(p.56-82)) CHEMISTRY OF AQUEOUS SYSTEMS. (Oak Ridge National Lab., Tenn.).

The solubilities of $Ag_2SO_4$ were measured in $KNO_3$-$K_2SO_4$, $K_2SO_4$-$MgSO_4$ and $K_2SO_4$-$H_2SO_4$ aqueous mixtures at 90 to 175°C. Expressions tried for representing the logarithm of the solubility product vs ionic strength include a single-parameter Debye-Hückel equation and a Debye-Hückel expression with fixed parameter plus a linear term with an adjustable parameter. The adjustable Debye-Hückel parameter was very nearly temperature independent, while the adjustable linear parameter varied quadratically with temperature in all mixed-electrolyte media. A generalized least-squares technique can be used to calculate equilibrium constants in solvent extraction equilibria by minimizing the difference between observed and calculated distribution ratios. The method was successfully applied to the extraction of uranyl nitrate and nitric acid by TBP dissolved in an inert diluent. The optical absorption of hydrolyzed U(VI) in 1 M chloride solutions was correlated with a hydrolysis scheme based on acidity and ultracentrifugation measurements, involving as principle species $(UO_2)_2(OH)_2^{2+}$, $(UO_2)_3(OH)_4^{2+}$, and $(UO_2)_3(OH)_5^+$. Ultracentrifugation of Bi(III) perchlorate solutions as a function of concentration and degree of hydrolysis indicates that estimates of equilibrium quotients and their temperature coefficients for polymeric reactions may be possible by comparing experimental equilibrium refractive index patterns with those computed on the basis of an assumed model. Equilibrium ultracentrifugations of hydrolyzed Pb(II) solutions in general confirm the scheme postulated on the basis of emf measurements carried out elsewhere. The $NbOF_5^{2-}$ ion and the $NbF_6^-$ ion were identified in 0% to 50% HF solutions by comparing the Raman spectra of the solutions with the spectra of crystalline $CsNbF_6$, $K_2NbF_7$, and $K_2NbOF_5 \cdot H_2O$. The $NbF_7^{2-}$ ion was not found in the solutions. A new spectrophotometer cell assembly was constructed for high-temperature aqueous spectrophotometric studies. In both sample and reference cells, temperature and pressure are precisely controlled, and liquid-gas equilibration is pro-

vided for. Preliminary study indicates that the $DClO_4$-$D_2O$-$H_2O$ system is a usable solvent for spectrophotometry of inorganic ions at least to 1f $DClO_4$, to 250°C, and over the wavelength range 0.33 to 1.8μ. The applicability of the mass law to ion exchange equilibria with concentrated aqueous salt solutions was demonstrated with a liquid anion exchanger. Equilibria involving concentrated hydrochloric acid solutions with both liquid and resinous anion exchangers, however, could not be rationalized because of the invasion of these exchangers by this electrolyte. An attractive explanation for this invasion and the associated large nonideality of the resultant organic phase was that hydrogen dichloride ions, $HCl_2^-$, were being formed at the exchange sites. Infrared absorption, vapor pressure and other measurements have appeared to give support to the explanation. Systematic measurements of the osmotic and activity coefficients at 25°C for a wide variety of quaternary ammonium halides in aqueous solutions as a function of concentration have continued. The degree of interaction between a given halide ion and the quaternary ammonium cation depended on the structure of the latter. For example, substitution of a benzyl for a methyl group greatly increased the anion binding of the resulting quaternary ammonium cation. Calorimetric measurements of the heat of exchange of bromide for chloride ion with high-molecular-weight linear anionic polyelectrolyte gave values in reasonable agreement with previously observed heats for the same reaction with cross-linked anion exchangers. Heat of solution and dilution measurements were completed on p-ethylbenzene sulfonic acid (the "model" compound for Dowex 50) and on the Li, Na, K, and Cs salts of the acid. The heat content-concentration dependency observed with these compounds was notable in that the initial slopes were larger than for any other common alkali-metal salt of the 1:1 type. The extraction of microquantities of Fe(III) from concentrated hydrochloric and perchloric acid solutions by a strong acid liquid cation exchanger and by a lightly cross-linked Dowex 50 were compared. In all four cases a marked increase in the extraction of iron above acid concentrations of 3 to 4 M was observed. A systematic study is in progress of the ion exchange properties of essentially all metallic elements with the objective of developing a general ion exchange separations scheme. Anion and cation exchange methods are being explored in HCl, $HNO_3$, $HClO_4$, $H_2SO_4$, and HF solutions and various mixtures of these acids. High-ionic-strength media are being stressed. Approximately six major ion exchange groups, which are expected to form the basis of a generalized scheme, have been evaluated. The cation exchange behavior of U(VI) was studied in mixtures of $HClO_4$, $HNO_3$, HCl, and $H_2SO_4$ solutions at high ionic strength. The presence of small amounts of chloride affects the adsorbability of U(VI) greatly. Some of the unique features of the adsorbability of U(VI) at high ionic strength can be utilized for a number of novel separations techniques. A large number of vanadates were found to have interesting cation exchange properties. Zirconium antimonate was found to be a cation exchanger with relatively unique selectivities. (auth)

**10512** (ORNL-3320(p.83-97)) ELECTROCHEMICAL KINETICS AND ITS APPLICATION TO CORROSION. (Oak Ridge National Lab., Tenn.).

Data and information are presented on ion exchange at the passive film on iron and steel, the role of $H_2$ penetration into the metal in the electrochemistry of iron, diffusion of $H_2$ through iron membranes, electrochemistry of Zr, passivity in iron alloys, and the differential capacity of the electrical double layer on electrolytic iron in neutral and acid solutions. (J.R.D.)

**10513** (ORNL-3320(p.98-103)) NONAQUEOUS SYSTEMS AT HIGH TEMPERATURE. (Oak Ridge National Lab., Tenn.).

Information and data are included concerning electrical conductivity of solutions of metals in their molten halides, electron exchange in molten rare earth halides, electric conductivity and complex ion formation in Cd–KCl melts, and heats of fusion of alkaline earth and rare earth metal halides. (J.R.D.)

**10514** (ORNL-3320(p.104-25)) CHEMICAL PHYSICS. (Oak Ridge National Lab., Tenn.).

The laboratories for paramagnetic resonance work were enlarged, and new spectrometers for studies at 9000 and 23,000 Mc were assembled and put into operation. Progress was made in the design of a new cavity for extending work to liquid-helium temperature. The single crystal paramagnetic resonance parameters of $NO_2$ in irradiated $NaNO_2$ and in irradiated $KNO_3$ were found to differ significantly. The differences are satisfactorily explained if $NO_2$ in $KNO_3$ is undergoing rapid reorientations between two mirror-related sites in a nitrate ion vacancy. Study of $KNO_3$ doped with N-labeled $NO_2^-$ showed that $NO_2$ is produced from $NO_2^-$ by irradiation at 77°K. Studies of the production of $NO_2$ suggest that $NO_2^-$ is not produced in pure $KNO_3$ at 77°K but is produced after the irradiated salt is warmed. A paramagnetic resonance study of irradiated single crystals of $H_2O_2$ has been reactivated. Conditions for forming three distinct spectra by ultraviolet irradiations have now been found. A paramagnetic species exhibiting $Cl_2$ hyperfine structure and believed to be $ClO_2$ was studied in gamma-irradiated $KClO_3$. Machine computations were made in an attempt to fit the data to a spin Hamiltonian which included the quadrupole interaction. If $Ba(ClO_3)_2 \cdot H_2O$ is irradiated at 77°K and then warmed to room temperature, a species with a similar spectrum is formed. The crystal structure of chloral hydrate was determined to high precision by three-dimensional neutron diffraction methods. Complete details of the molecular structure and $H_2$ bonding were elucidated. Neutron diffraction measurements on NaCl, KCl, and RbCl single crystals demonstrated the consistency and precision of intensity measurements with the Oak Ridge automatic neutron diffractometer, refined the values for the nuclear scattering amplitudes of the metals relative to Cl, and yielded precise values of the thermal-displacement parameters in these crystals. X ray diffraction studies of structure in molten alkali halides and aqueous solutions are continuing. Work on liquid water and on aqueous $Pb(OH)ClO_4$ is nearing completion. The data for water are consistent with a model based on the ordinary ice structure, with "interstitial" water molecules filling approximately half the ice structure cavities. The $Pb(OH)ClO_4$ data were interpreted in terms of a model containing a tetrahedral arrangement of lead atoms, each lead atom having three other lead atom neighbors at a distance of about 3.83 A. A program was prepared to plot contours of a two-dimensional density function using the California Computer Products model 570 magnetic tape plotter. An experimental computer program was prepared which will postulate crystal structures when given the unit cell size, symmetry, and number of molecules per cell. Several computer programs for crystallographic calculations were rewritten in FORTRAN language in order to permit their use on different machines and to facilitate any modifications which may become necessary. Low-temperature heat capacity measurements on a third preparation of $K_2ReBr_6$ agree poorly with previous measurements. This places a large uncertainty upon the calculated entropy; the revised

value is $S^0(298.16°K) = 108.0 \pm 1.5$ cal $deg^{-1}$ $mole^{-1}$. The heat of mixing in the molten-salt system LiF-KF was measured with the Bunsen ice calorimeter as a function of composition. The system exhibits energetic asymmetry and has a maximum heat of solution of about 1200 cal/mole. In a mass spectrometric study of both the catalytic decomposition of ammonia on Pt and its radiolytic decomposition by 90-ev electrons, the $NH_4^+$ ion was the most abundant transient species observed. The two-stage mass spectrometer was developed into a highly sensitive and reliable instrument for the accurate determination of isotopic abundance ratios. In preliminary experiments with crossed molecular beams of D and $H_2$, it was possible to observe part of the angular distribution of the product HD. If the results can be taken at their face value, they present an ambiguity concerning the distribution of the energy between various internal modes. In the same apparatus, a surprising specularity was observed in the reflection of $D_2$ and He beams from a polycrystalline Pt foil. The differential surface-ionization detector for alkali metals and their compounds was revised to eliminate previous difficulties caused by scattering from supporting members of the gage. A fast surface-ionization detector with electron multiplier was constructed and found to be satisfactory for use with phase-sensitive detection. A velocity selector was also built and tested. (auth)

**10515** (ORNL-3380) EVALUATION OF A REDUCED PRESSURE BACKFLOW PREVENTER USING ACTIVATION ANALYSIS. Justus N. Baird, Jr., W. R. Sanford, and G. A. Cristy (Oak Ridge National Lab., Tenn.). Jan. 9, 1963. Contract W-7405-eng-26. 51p.

Despite its advantages of economy and convenience, the reduced-pressure-principle backflow preventer was only partially accepted as a substitute for air-gap separation in preventing pollution of potable water. To evaluate the protection provided by a reduced pressure principle backflow preventer, a unit was tested under the following static conditions; ionic diffusion, lower pressure on the supply side than on the discharge side, vacuum on the supply side, water hammer on the supply side, and water hammer on the discharge side. Using a solution of Mn and K nitrates as a nonradioactive tracer, backflow from the discharge side to the supply side was not detectable by activation and radiochemical analyses having a sensitivity of ~0.2 ppb Mn. The protection factor for the device is defined as: P. F. = (Reagent concentration in the discharge zone/Reagent concentration in the supply zone due to backflow). The minimum protection factor proved in these tests based upon the limit of the sensitivity of Mn analysis is $6.5 \times 10^8$. This factor provides a rational basis for installation where the concentration of radioactivity or other contaminant can be estimated, measured, or limited. The K analyses also showed no detection of backflow but with a lesser sensitivity. (auth)

**10516** (ORNL-TM-475) THERMAL AND RADIATION STABILITY OF SUGGESTED ALTERNATIVE GAS COOLANTS. W. T. Rainey, Jr. and R. L. Bennett (Oak Ridge National Lab., Tenn.). Feb. 5, 1963. Contract [W-7405-eng-26]. 6p.

A literature survey was made to evaluate the thermal and radiation stabilities of several gases which were proposed tentatively as reactor coolants. Available thermodynamic stability data are listed. For each gas a summary is presented of the available information concerning stabilities and chemical reactivity with reactor materials and contaminants. Because of their low thermal stabilities, $B_2H_6$, $SiH_4$, and $NF_3$ are not recommended. Radiolytic decomposition and expense of removal of $B^{10}$ probably eliminate the use of $BF_3$. Little data are available concerning $MoF_6$, $MoF_5$ and $NbF_5$, but these compounds do not appear to have large stabilities. Radiolytic damage to $CF_4$ gives a G value for the production of fluorine of 0.28. No radiation information is available for $SiF_4$ and $SF_6$. An experimental investigation of the more promising gases ($SF_6$, $SiF_4$ and $CF_4$) is proposed. This would include radiation at ambient and high temperatures as well as reactivity studies with carbon and reactor contaminants. (auth)

**10517** (PAN-336/XIII) THE SYNTHESIS OF C-14-LABELLED METHYLAMINE HYDROCHLORIDE. Maria Wolska-Witerowa (Polish Academy of Sciences. Inst. of Nuclear Research, Warsaw). June 1962. 8p.

The conditions are described for the semimicro synthesis of sodium and potassium cyanides from barium $C^{14}$ carbonate by ammoniacal reduction in Carius tubes, and the synthesis-reduction of the obtained $C^{14}$ cyanides, in a sulfuric acid medium, leading to $C^{14}$ methylamine. The following yields of the products were obtained: for $KC^{14}N$, on a 0.5 mM scale, over 90%, and for $C^{14}H_3NH_2 \cdot HCl$, on a 4 mM scale, 98% as compared with the cyanide quantity. (auth)

**10518** (TID-17823) ELECTROCHEMISTRY AND THERMOCHEMISTRY IN FUSED SALTS. Annual Progress Report, August 16, 1961–December 31, 1962. Joseph Jordan (Pennsylvania State Univ., University Park. Coll. of Chemistry and Physics). Jan. 10, 1963. Contract AT(30-1)-2133. 33p.

Activities during the second half of 1961 and the year 1962 are reviewed. Throughout this time-period, experimental studies were continued on polarography (at the dropping mercury electrode and at rotated Pt disk microelectrodes) in molten nitrate solvents and enthalpy titrations in chloride melts. Tracer autoradiography studies of electrodeposits were continued. Significant recent results include those concerning evidence of association of anions, yielding "polychromate", "polycyanide", and "polynitrate" species; utilization of a voltammetric water reduction wave for estimating moisture content of molten nitrates; anodic depolarization waves at the dropping mercury electrode in fused nitrates, in the presence of hydroxide, chloride, bromide and cyanide; a well-defined anodic wave of carbonate in nitrate solvents at Pt indicator electrodes; and an exothermic oxidation (at 400°C) of trivalent Cr to a hexavalent chromate species by nitrate ions in molten chloride media. Plans for future work are outlined. (J.R.D.)

**10519** (EURAEC-460) RETREATMENT OF IRRADIATED FUELS. Quarterly Report No. 6, July 1 to September 30, 1962. (Mol, Belgium. Centre d'Etude de l'Energie Nucleaire). Work Performed under United States–Euratom Joint Research and Development Program. Contract 049-61-4-RDB. 55p. A translation.

The chlorination of uranium oxides, oxidation kinetics, elimination of fission products, powder technology, and plutonium separation are discussed in detail and progress is indicated on problem areas. (W.D.M.)

**10520** (NP-tr-946) INTRODUCTION TO THE THEORY OF BRANCHING STOCHASTIC PROCESSES. B. A. Sevast'yanov. Translated from Usp. Mat. Nauk, 6: No. 6, 47-99(Nov.-Dec. 1951). 5p.

Phenomena which are connected with the transformation of particles of one type into particles of another type are discussed, along with calculational methods for investigating the phenomena. The branching stochastic processes are shown to provide an effective solution to the

problem of finding a law of distribution of the number of particles at each moment of time of the process. Equations are presented for investigating branching processes. (M.C.G.)

**10521** ISOTOPIC EFFECTS IN SYSTEMS CONTAINING AN AMINE AND CARBON DIOXIDE. Karl Erik Holmberg (AB Atomenergi, Studsvik, Tystberga, Sweden). Acta Chem. Scand., 16: 2117-22(1962). (In English)

On distillation of compounds of lower amines with carbon dioxide, in which compounds are dissociated in the gas phase, there is an enrichment of several isotopes generally with the elementary factors: $\alpha(N^{14}/N^{15}) = 1.013$, $\alpha(O^{18}/O^{16}) = 1.006 - 1.010$, and $\alpha(C^{12}/C^{13}) = 1.0025$. The $N^{14}/N^{15}$ isotope enriches in the vapor during distillation. The vapor pressure of a secondary amine, deuterated at the nitrogen, by distillation with carbon dioxide becomes 7 to 9% higher than that of the undeuterated compound at the temperature corresponding to the normal boiling point of the latter. (auth)

## Analytical Procedures

*Refer also to abstract 10298.*

**10522** (ANL-6637) PROCEEDINGS OF THE SEVENTH ANNUAL MEETING ON BIO-ASSAY AND ANALYTICAL CHEMISTRY, HELD AT ARGONNE NATIONAL LABORATORY, OCTOBER 12-13, 1961. (Argonne National Lab., Ill.). Contract W-31-109-eng-38. 100p.

Separate abstracts were prepared on 9 papers included in this report. (C.H.)

**10523** (ANL-6637(p.5-8)) INFLUENCE OF PHYSICAL STATE ON THE REMOVAL OF HYDROLYZABLE RADIOELEMENTS BY CHELATION. Joan F. Fried (Argonne National Lab., Ill.).

The effects of the physical and chemical state of hydrolyzable radioelements on distribution in the body and ease of removal by chelation are discussed. Results are reported from two experiments in rats in which diethylenetriaminepentaacetic acid (CaDTPA) was used as the chelating agent for the removal of $Th^{234}$ and $Pu^{239}$. Thorium was prepared as the nitrate with a small amount of carrier added and as the citrate with no added carrier. The nitrate solution was colloidal and the citrate was largely ionic. In the second experiment two solutions of Pu were prepared in the same manner. Data are presented on distribution in tissue and the effectiveness of CaDTPA therapy on removal of ionic and colloidal forms of the radioisotopes. (C.H.)

**10524** (ANL-6637(p.13-21)) THE ESTIMATION OF A BODY BURDEN OF Pu FROM URINALYSIS DATA. Walter S. Snyder (Oak Ridge National Lab., Tenn.).

A method is presented for the mathematical analysis of data on $Pu^{239}$ excreted in urine for the estimation of body burden in humans. Factors affecting the accuracy of the method are discussed. (C.H.)

**10525** (ANL-6637(p.23-8)) THE DETERMINATION OF GROSS BETA AND GROSS ALPHA ACTIVITY IN URINE. B. D. Gunter and T. B. Smiley, Jr. (General Dynamics/Fort Worth. Div. of General Dynamics Corp., Fort Worth, Tex.).

Procedures are described for the determination of gross $\beta$ and $\alpha$ activity in urine samples. The procedure provides an effective means of screening routine urine samples. The dried precipitate is counted in an internal flow proportional counter. Samples showing high gross activities are subjected to specific identification techniques. (C.H.)

**10526** (ANL-6637(p.29-31)) THE DETERMINATION OF $\beta$-EMITTING RADIONUCLIDES IN AQUEOUS FORMAMIDE SOLUTIONS. A. Schwebel (National Bureau of Standards, Washington, D. C.).

Procedures are described for the assay of $\beta$-emitting radionuclides in aqueous formamide solutions. The planchets used for $C^{14}$ were filled with 1 ml of solution for counting. The detection equipment was calibrated by counting a known solution previously calibrated by an absolute counting technique. Data are tabulated on the efficiency of the method for various radionuclides. (C.H.)

**10527** (ANL-6637(p.33-42)) INITIAL TWO-YEAR EXPERIENCE WITH THE SAVANNAH RIVER PLANT PLUTONIUM URINALYSIS PROCEDURE. W. R. Jacobsen (Du Pont de Nemours (E. I.) & Co. Savannah River Plant, Aiken, S. C.).

An analytical procedure is described for the analysis of urine for Pu. The method consists of wet ashing the urine, purification of the Pu by anion exchange, elution by $H_2SO_4$, and electrodeposition in nitrate media on a stainless steel disc that is autoradiographed on nuclear track emulsion plates and the resulting tracks magnified and counted by a microprojector. Data accumulated during two years of experience with the method are summarized. (C.H.)

**10528** (ANL-6637(p.43-57)) CRITICALITY AND CRITICALITY CONTROL. J. E. McLaughlin, Jr. (New York Operations Office. Health and Safety Lab., AEC).

The criticality process is reviewed. The prevention of criticality in systems normally subcritical and the prevention of supercriticality in systems normally critical are considered from the viewpoint of nuclear safety. (C.H.)

**10529** (ANL-6637(p.59-84)) DETERMINATION OF ENVIRONMENTAL LEVELS OF RADIUM. N. Irving Sax, Mary Beigel, James C. Daly, and J. J. Gabay (New York. State Dept. of Health, Albany).

A model miniature community was used in a study of the effects of environmental $Ra^{226}$ contamination on the average intake of $Ra^{226}$. The feasibility of intake-output studies was also tested. Samples of food, hair, blood, urine, and feces were analyzed for $Ra^{226}$. Analytical methods are outlined. (C.H.)

**10530** (ANL-6637(p.85-95)) RADIUM-226 IN THE DIET IN THREE U. S. CITIES. Naomi A. Hallden, Isabel M. Fisenne, and John H. Harley (New York Operations Office. Health and Safety Lab., AEC).

The content of $Ra^{226}$ in the average diet was determined for New York, Chicago, and San Francisco. Radium was recovered as a by-product of a procedure for measuring the $Sr^{90}$ content of foods. The emanation techniques used for determining $Ra^{226}$ are described. (C.H.)

**10531** (ANL-6637(p.97-9)) COMPARISON OF TWO METHODS FOR DETERMINING RADIUM-226 IN SOIL SAMPLES. James Lamb (New York Operations Office. Health and Safety Lab., AEC).

A comparison is made of the sodium carbonate-fusion and the nitric acid-leaching methods of determining $Ra^{226}$ in soil samples. It is concluded that the leaching method is a simplified and direct method for use with a sediment-type soil. (C.H.)

**10532** (HW-SA-2554) AIR MONITOR AND PROTECTION—A COINCIDENCE-COUNT ALPHA PARTICULATE AIR MONITOR. M. O. Rankin, D. P. Brown, C. D. Boyne, and W. G. Spear (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 14, 1962. Contract [AT(45-1)-1350]. 11p.

The detection of the $Pu^{239}$ maximum permissible air

concentration (MPC) of $2 \times 10^{-12}$ μc/cc is complicated by a varying background of natural alpha emitters. The air concentration of radon and thoron, in particular, varies considerably with atmospheric conditions. Since one MPC of airborne $Pu^{239}$ is only $4.44 \times 10^{-6}$ dpm/cc, it is necessary to integrate the activity on a fixed filter to obtain adequate measurement sensitivity. Radon and thoron are also collected on the filter, and at times may accumulate to several hundred times the required detection level for $Pu^{239}$. An instrument using coincidence counting techniques was developed to measure the $Pu^{239}$ air concentration levels. In the decay chain for radon, Ra C decays by beta emission to Ra C′ which decays by alpha emission with a half life of 163 μ sec; and in the similar thoron chain, Th C decays by beta emission to Th C′ which decays by alpha emission with a half life for 0.3 μ sec. Delayed coincidence-counting techniques are used to identify counts due to natural alpha particles, and these counts are subtracted from a total alpha count to provide a measurement of $Pu^{239}$. The developed instrument can detect continuous airborne $Pu^{239}$ concentrations of $2 \times 10^{-11}$ μc/cc in about 90 minutes and $2 \times 10^{-12}$ μc/cc in about 900 minutes. These detection levels can be obtained with background Ra–Th concentration levels of $2 \times 10^{-10}$ μc/cc. (auth)

**10533** (HW-SA-2657) SPECTROPHOTOMETRIC DETERMINATION OF NEPTUNIUM. Curtis A. Colvin (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). June 12, 1962. Contract AT(45-1)-1350. 8p.

A rapid, accurate determination of Np above 0.05 g/l, with practically no interference from other ions is described. Np is oxidized to the hexavalent state which has an absorption peak at 1.23 microns. The peak obeys Beer's Law and is specific as far as ions normally encountered in process solutions are concerned. Hexavalent Cr is used as the oxidant, which readily oxidizes Np in acid solutions at ambient temperatures. Possible incomplete oxidation, which is corrected by heating the sample, is quickly detected when using a recording spectrophotometer. (auth)

**10534** (IA-784) ANALYTICAL ASPECTS OF DELAYED NEUTRON EMISSION. S. Amiel and M. Peisach (Israel. Atomic Energy Commission, Rehovoth). Oct. 1962. 35p.

The technique of using delayed neutron emission for analysis is investigated, and the application of delayed neutron emission from fission is made to analyses of uranium, thorium, and other fissionable nuclides. Emission from nitrogen-17 is used for analyses of lithium, lithium-6, and oxygen-18. Other analytical uses of nitrogen-17 are mentioned, and equipment used is described. (D.C.W.)

**10535** (JINR-P-1118) RADIOGRAFIYA SPONTANNOGO DELENIYA YADER. (Radiography of Spontaneous Nuclear Fission). V. P. Perelygin and S. P. Tret'yakova (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Reactions). 1962. 5p.

A technique for registering the spontaneous fission fragments is described by which the radiography of the mendelevium and fermium elements separated by a chromatographic column can be obtained. (auth)

**10536** (NP-12398) X-RAY ABSORPTION METHOD FOR DETERMINING THE TBP CONTENT OF KEROSENE-BASED EXTRACTION SOLVENTS. Eurochemic Technical Report No. 132. B. Edwall and P. Wichmann (European Company for the Chemical Processing of Irradiated Fuels, Mol, Belgium). Jan. 16, 1962. 12p.

A rapid and exact x-ray absorption method for the determination of the TBP content of kerosene-based solvents was studied. The wavelengths used are either Cu Kα, Fe Kα, or Mn Kα lines which are more strongly absorbed by TBP than the other components of the mixture. After the basic studies made with a Siemens crystalloflex, an instrument was constructed, using $Fe^{55}$ as the x-ray source. (auth)

**10537** (TID-15724) APPROACHES TO MASS-SPECTROMETER GAS ANALYSIS USING PHOTOGRAPHIC-PLATE ION DETECTION. J. W. Guthrie (Sandia Corp., Albuquerque, N. Mex.). [May 18, 1962]. Contract [AT(29-1)-789]. 11p. (SCDC-2575)

An analytical technique developed in an investigation of ion detection by photographic plate for use in measuring the normal methane and complex methane in gas mixtures is described. The complex methane resulted from exchange reactions between methane and hydrogen, deuterium, or tritium. The samples of interest contained two He isotopes and atmospheric gases. Potential uses of the scheme are discussed. (J.R.D.)

**10538** (TID-16295) THE EFFECTS OF VARIOUS GRADES OF GRAPHITE ELECTRODES ON THE CARRIER DISTILLATION OF IMPURITIES IN $U_3O_8$. C. E. Pepper, A. J. Pardi, and M. G. Atwell (National Lead Co. of Ohio, Cincinnati). [1961]. Contract AT(30-1)-1156. 40p.

Seven grades of graphite electrodes were evaluated for their effects upon the carrier distillation excitation of impurities in $U_3O_8$. Two carrier materials, AgCl–LiF (11 : 1) and $Ga_2O_3$, were independently investigated using a spectrograph and a quantometer. Time resolved spectra for 19 impurities were made by recording the instantaneous response of each impurity in the arc for each type of graphite electrode. Elemental sensitivity comparisons were made from the measured area under each spectral recording. Analytical curves for seven impurities (B, Cr, Cu, Fe, Mn, Ni, and Si) were prepared for each graphite type. The analytical precisions of these elements for each graphite were determined from replicate analyses of common $U_3O_8$ samples. A comparison of these precisions is presented for both carrier materials. The accumulated comparative data permit a choice of the graphite types which provide the greatest advantages for the determination of impurities in $U_3O_8$ with carrier distillation techniques. (auth)

**10539** (TID-16296) DETERMINATION OF CHROMIUM, COBALT, IRON, AND NICKEL IN ALLOYS. B. T. Kenna and F. J. Conrad (Sandia Corp., Albuquerque, N. Mex.). July 1962. Contract AT(29-1)-789. 16p. (SCDC-2735)

A procedure is given for the separation of chromium, cobalt, iron, and nickel by utilizing anion exchange with hydrochloric acid as an eluant. Quantitative determinations of these elements are made by standard methods. (auth)

**10540** (TID-17745) UTILIZATION OF TRICAPRYLMETHYLAMMONIUM THIOCYANATE AS A SELECTIVE EXTRACTION AGENT IN THE SPECTROPHOTOMETRIC DETERMINATION OF COBALT. A. M. Wilson and O. K. McFarland (Wayne State Univ., Detroit). [1962]. Contract AT(11-1)-775. 22p.

Tricaprylmethylammonium thiocyanate dissolved in benzene is a strong liquid ion exchanger which completely extracts the blue cobalt(II) thiocyanate complex in one equilibration. The buffered extraction solution (pH 8.0) contains sodium citrate, which completely masks the ferric ion interference. An unbuffered scrub solution containing sodium thiocyanate, sodium citrate, and sodium thiosulfate completely removes the cupric and nickelous ion interferences in one equilibration. The described procedure allows Co to be determined in the presence of ferric,

nickelous and cupric ions at mole ratios 1000, 480, and 250 times that of Co, respectively. Co determination results of National Bureau of Standards alloys are presented. (auth)

**10541** (EURAEC-400) APPLICATION OF TRANSIENT ELECTROCHEMICAL METHODS TO THE CHEMICAL ANALYSIS OF PRODUCTS CONCERNING NUCLEAR CHEMISTRY. Quarterly Report No. 8, April 1–June 30, 1962. (Brussels. Université). Work Performed under United States–Euratom Joint Research and Development Program. Contract 018-60-7-RDB. 24p. A translation.

A study of the electrochemical behavior of U in acid and basic medium was continued. It was found that small additions of thiocyanate ions accelerate the dismutation process such that the reactions proceed quantitatively to U(IV). A study of the reaction mechanism in carbonate resulted in definition and control of the factors affecting the position of the polarization curves. (J.R.D.)

**10542** A SIMPLIFIED METHOD FOR THE DETERMINATION OF ARSENIC BY MEANS OF ACTIVATION ANALYSIS. Roland Christell and Bernt Sjoestrand (Royal Inst. of Tech., Stockholm). Acta Chem. Scand., 16: 2123-30(1962). (In English)

A simple and rapid method for determination of As in virtually all sorts of biological materials and also in other cases by means of activation analysis was developed and evaluated. Arsenic is separated radiochemically by distillation and precipitation and the radioactivity of $As^{76}$ measured by $\gamma$ spectrometry or $\beta^-$-counting. The sensitivity is $10^{-8}$ to $10^{-9}$ g, depending on the measurement technique, when irradiation is performed at a flux of the order of $10^{12}$ neutrons $cm^{-2}$ $sec^{-1}$. The procedure was applied to the determination of the As content of the remains of the 16th century King Erik XIV of Sweden and of other materials. (auth)

**10543** A SEMIAUTOMATIC DEVICE FOR MEASURING RADIOACTIVITY ON TWO-DIMENSIONAL PAPER CHROMATOGRAMS. V. Moses and K. K. Lonberg-Holm (Univ. of California, Berkeley). Anal. Biochem., 5: 11-27(Jan. 1963). (UCRL-10112)

A technique was developed for the automatic measurement of radioactivity on 2-dimensional paper chromatograms. The positions of radioactive compounds on the chromatograms are determined by radioautography and the appropriate areas are cut out from the chromatogram. The excised chromatogram spots are sandwiched between two continuous bands of thin plastic polyester film in an apparatus designed for this purpose. In another apparatus, the accumulated double band of polyester film bearing the chromatogram spots is automatically passed in a discontinuous manner between two closely opposed detector tubes. Each spot remains stationary between the detector tubes for a predetermined counting period. For each chromatogram spot the number of counts recorded, together with the elapsed time, is automatically printed onto paper tape. The double band of polyester film is then automatically advanced until the next spot lies between the detector tubes, and the cycle is repeated. (P.C.H.)

**10544** POLAROGRAPHY OF NIOBIUM-EDTA COMPLEXES. Robert Kirby and Henry Freiser (Univ. of Arizona, Tucson). Anal. Chem., 35: 122-5(Feb. 1963).

The polarography of Nb(V) in EDTA solutions was studied in detail. Two reduction waves were obtained. The first, a reversible 1-electron reduction to Nb(IV), involved varying amounts of H ion, depending on the pH region. The diffusion current of the Nb(V)-EDTA complex varied linearly with concentration between the limits of 0.50 and 1000 $\mu$g of Nb per ml with a precision of ±2.0%. Preliminary heating of the solution was required to obtain the maximum diffusion current. An analytical procedure based upon this behavior was developed, capable of an accuracy of ±2.0%. Tantalum may be tolerated to a ratio of 2:1, Ta:Nb. (auth)

**10545** CONTROLLED-POTENTIAL COULOMETRIC TITRATION OF URANIUM(IV) AND URANIUM(VI) IN SODIUM TRIPOLYPHOSPHATE MEDIUM. H. E. Zittel and Louise B. Dunlap (Oak Ridge National Lab., Tenn.). Anal. Chem., 35: 125-8(Feb. 1963).

The U(IV) and U(VI) contents of a sample can be determined by controlled-potential coulometric titration. Both the oxidation and reduction reactions take place at a mercury-pool electrode in a supporting electrolyte that is 6 w/v % sodium tripolyphosphate solution adjusted to pH 7.5 to 9.5. The U(VI) is reduced coulometrically at a potential of –1.35 volts vs S.C.E. The reduction is a direct measure of the U(VI) present. The same test portion is then oxidized coulometrically at +0.1 volt vs S.C.E. The oxidation is a measure of the total U present; the U(IV) content is found by difference. In the range of total U content from 2 to 10 mg, the error of the method is approximately 1%. Various possible interferences were studied; only Cu(II) and Fe(III) caused any significant error. (auth)

**10546** NEUTRON ACTIVATION ANALYSIS OF ALUMINUM. DETERMINATION OF GAMMA-EMITTING IMPURITIES WITH LONG HALF LIVES. Francesco Girardi and Romano Pietra (Centro Comune di Ricerche Euratom, Ispra, Italy). Anal. Chem., 35: 173-7(Feb. 1963).

A separation scheme is presented for the systematic determination by neutron activation of 13 trace impurities in Al for nuclear reactor technology. The determinations are based on a group separation of the activated nuclides in the carrier free state by ion exchange, isotopic exchange, and coprecipitation. The separated fractions are then analyzed by $\gamma$ spectrometry. All the impurities that give rise to long-lived gamma-emitting isotopes were considered. Quantitative separation was studied for the most common impurities and for the elements of greater importance from a nuclear standpoint. The presence of other impurities may be detected and their quantity may be roughly estimated by analysis of the gamma spectra of the separated fractions. The rare earths are separated as a whole. The carrier free state makes the final separation of individual rare earths simpler and faster. The absence of gravimetric yield determinations results in a considerable saving of time. The complete analysis requires 7 hr, including the activity measurements. Automation of the ion exchange separations decreased the operating time still further. (auth)

**10547** EVALUATION OF RADIOACTIVE DECAY DATA. Robert G. Monk, Alan Mercer, and Tom Downham (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). Anal. Chem., 35: 178-83(Feb. 1963).

Methods of evaluating the individual component activities of a mixed source from radioactive decay data are compared by applying them to counting data from sources prepared by mixing known amounts of $Mo^{99}$ and $La^{140}$. The most suitable equations are shown to be the maximum likelihood and minimum chi-squared, and recommendations are made as to their practical application to minimize possible sources of error. (auth)

**10548** CATION EXCHANGE SEPARATION AND SPECTROGRAPHIC DETERMINATION OF SOLUBLE SILICON IN PLUTONIUM. Charles E. Pietri and Albert W. Wenzel (U. S. Atomic Energy Commission New Brunswick, N. J.). Anal. Chem., 35: 209-11(Feb. 1963).

A cation exchange separation of Si from Pu is made prior

to spectrographic determination to reduce the health hazard and spectral interference from Pu. Boiler cap electrodes in conjunction with a sodium carbonate buffer double the sensitivity normally obtained without caps in the same direct current arc methods. The lower limit of detection is 1 ppm Si. The over-all relative standard deviation of the method was within ±9%. (auth)

**10549** ATOMIC ABSORPTION SPECTRA OF VANADIUM, TITANIUM, NIOBIUM, SCANDIUM, YTTRIUM, AND RHENIUM. Velmer A. Fassel and Victor G. Mossotti (Ames Lab., Ames, Iowa). Anal. Chem., 35: 252-3(Feb. 1963). (IS-583)

Analytically useful atomic absorption spectra of V, Ti, Nb, Sc, Y, and Re were observed in highly fuel-rich, oxyacetylene flames. The wavelengths of the strongest absorption lines of the elements and their sensitivities of detection are tabulated. The sensitivities of detection are expressed as the concentrations required to produce a visually detected absorption line. The lines exhibit adequate sensitivity to satisfy many analytical requirements. (P.C.H.)

**10550** THE DETERMINATION OF THALLIUM IN URINE. M. Ariel and D. Bach (Technion-Israel Inst. of Tech., Haifa). Analyst, 88: 30-5(Jan. 1963).

A method was developed in which Brilliant green is used for the spectrophotometric determination of thallium in urine. The thallium–Brilliant green complex, formed in the presence of the organic substrate, is extracted into toluene. The optimum conditions for the determination are described, and the sources of various interferences examined. The method was used to check thallium excretion in the urine of patients. (auth)

**10551** A RAPID ASSAY OF RADIOACTIVE CAESIUM IN MILK. R. W. C. Broadbank, J. D. Hands, and R. D. Harding (College of Tech. and Commerce, Leicester, Eng.). Analyst, 88: 43-6(Jan. 1963).

A rapid method for the assay of radioactive cesium in milk is described. It involves ashing the sample and separating cesium by allowing a solution of the ash in nitric acid to flow through a bed of ammonium 12-molybdophosphate. The assay is completed by beta-counting the bed of ammonium 12-molybdophosphate. (auth)

**10552** A LIQUID-SCINTILLATION METHOD FOR DETERMINING TRITIUM IN THE TISSUES OF ANIMALS DOSED WITH TRITIUM-LABELLED VITAMIN A. J. A. Handler (Royal Veterinary and Agricultural Coll., Copenhagen). Analyst, 88: 47-55(Jan. 1963).

A liquid-scintillation counting method is described for determining tritium as tritium-labeled vitamin A in suspensions of tissue, blood, and feces. Some problems of the method are examined, such as the influence on the measurements of the composition of the scintillator and the auxiliary compound, anhydrous sodium sulfate. The use of an internal standard is described, and the range of error and evaluation of the results are discussed. Finally, the procedure is described in detail and results are reported that show good agreement between this method and the conventional method for determining vitamin A. (auth)

**10553** THE DETERMINATION OF STRONTIUM IN TAP-WATER BY X-RAY FLUORESCENCE SPECTROMETRY. R. G. Stone (Department of Scientific and Industrial Research, London). Analyst, 88: 56-8(Jan. 1963).

A method is described for determining natural strontium in tap-water by x-ray fluorescence analysis as a preliminary step to the determination of the $Sr^{90}$ content. Calcium and strontium are co-precipitated as oxalates and converted to nitrates. A known amount of rubidium is added as internal standard and the ratio of the intensities of the strontium K$\alpha$ and rubidium K$\alpha$ lines measured. The rubidium internal standard compensates for the absorption effect of the varying concentration of calcium present in tap-waters, and a linear relationship exists between the intensity ratio of the strontium and rubidium K$\alpha$ radiation and the weight ratio of strontium to rubidium in the prepared sample. (auth)

**10554** RAPID DETERMINATION OF IODINE-131 IN MILK. A. L. Boni (E. I. du Pont de Nemours and Co., Aiken, S. C.). Analyst, 88: 64-6(Jan. 1963).

A method is described for the rapid determination of $I^{131}$ in milk by direct absorption of $I^{131}$ on anion-exchange resin and subsequent gamma-spectrometric analysis of the resin. The method requires less than 2 hr per 1 gal sample and a counting time of only 10 min to achieve a minimum detection limit of $3.5 \times 10^{-15}$ C per ml. The anion-exchange concentration step completely eliminates the interference of all other fission-product contaminants found in milk except $Ru^{103}$, $Ru^{106}$, and $Zr\text{-}Nb^{95}$. An average recovery of 98% was experienced. (P.C.H.)

**10555** A SIMPLE METHOD OF MEASURING LOW URANIUM CONCENTRATIONS IN NATURAL CRYSTALS. P. B. Price and R. M. Walker (General Electric Research Lab., Schenectady, N. Y.). Appl. Phys. Letters, 2: 23-5 (Jan. 15, 1963).

Information from previous investigations on radiation-damaged material was used to provide a simple and sensitive way of measuring uranium concentrations as low as $4 \times 10^{-15}$ in micaceous minerals. The linear regions of radiation damage can be enlarged to optical dimensions by etching the mineral in hydrofluoric acid. After the sample is etched to determine the number of background tracks, it is exposed to thermal neutrons in a reactor to induce fission of the uranium impurities. The sample is then re-etched to determine the number of new tracks. A formula for calculating the number of fragments crossing a given surface in the interior of a thick sample is used to determine the concentration of uranium in the sample. By using a high purity mica crystal as a detector, this method can be applied to any natural mineral. (C.E.S.)

**10556** DECOMPOSITION OF MONAZITE SAND WITH PYROPHOSPHORIC ACID. B. Marchand (Universität, Freiburg i. B.). Atomkernenergie, 7: 371-2(Oct. 1962). (In German)

A method for the decomposition of monazite sand using pyrophosphoric acid was reported, and its utility for the rapid analytical determination of the Th concentration of the sand was shown. Step-by-step procedures are given for the decomposition and analysis. (J.S.R.)

**10557** A MASS-SPECTROSCOPIC STUDY OF THE CARBOHYDRATES. THE METHYL ETHERS OF THE MONOSACCHARIDES. N. K. Kochetkov, N. S. Vul'fson, O. S. Chizhov, and B. M. Zolotarev (Inst. of Chemistry of Natural Compounds, Academy of Sciences, USSR). Doklady Akad. Nauk SSSR, 147: 1369-72(Dec. 21, 1962). (In Russian)

Mass-spectra were run on 2, 3, 5, 6-tetramethyl-D-glucopyranose (I), 2, 3, 5, 6-tetramethyl-D-glucofuranose (II), 2, 3, 4, 6-tetramethyl-D-galactopyranose (III), 2, 3, 4-trimethyl-D-xylopyranose (IV), 2, 3, 4-trimethyl-L-rhamnopyranose (V), and 2, 3, 5-trimethyl-arabofuranose (VI) in order to elucidate the structure of natural sugars. The sample of sugar was broken in a stainless steel chamber held at 175°C, and the vapors leaked into the ionization chamber of the mass-spectrometer. The spectra were readily reproducible. The principal spectral line was taken as 100%, and the other peaks were calculated as a percentage of this line. Mass peaks of 101, 88, and 45 were the most prominent in spectra of compounds I, III, and IV. The

methylated pyranoses I and III could be distinguished, because the mass 85 and 45 peaks in compound I were 65 and 63% of the mass 101 peak, while in compound III, the mass 45 peak had an intensity of 39%, and the mass 88 peak had an intensity of 44% of the mass 101 peak. The structurally similar compound IV differed from the spectra of I and III by the absence of the mass 191 and 218 peaks and by having a different mass 45 and 88 ratio. Compound V differed from compounds I, III, and IV by having high mass 43, 75, and 88 peaks. The data showed that the spectra are characteristic of the sugar, and can be used to distinguish one sugar from the other. (TTT)

**10558** A COMBINATION OF A GAS CHROMATOGRAPH WITH A MASS SPECTROGRAPH. Hans Widmer and Tino Gaeumann (Technische Hochschule, Zurich). Helv. Chim. Acta, 45: 2175-85(1962). (In German)

The direct combination of a gas chromatograph with a time-of-flight mass spectrometer is described. The advantages over the method of sampling the different gas-chromatographic peaks are high sensitivity, high gas-chromatographic resolution, and speed of recording. The main difficulties encountered when working with small concentrations are memory effect, low abundance sensitivity, and gas noise with the same frequency distribution as the flicker noise of thermal cathodes. (auth)

**10559** CONCERNING THE PHYSICAL BASIS FOR THE DETERMINATION OF MOISTURE IN PEAT BY MEANS OF THE NEUTRON METHOD. Ya. Chudars and N. Skvortsova. Latvijas PSR Zinatnu Akad. Vestis, No. 5, 75-83(1962). (In Russian)

The theoretical and experimental possibility of applying the neutron method to the measurement of moisture in peat is discussed. To this end the stopping of neutrons in peat and water was compared. The stopping length of neutrons was determined by considering the stopping lengths of the separate elements in peat, C, H, N, and O. It was found that the ratio of lengths $L_{peat}/L_{water}$ changes little with energy; but the ratio is characteristic of the particular source of neutrons used, such as a Po–Be source. Experiments are described in which the stopping length of water is determined to be 6.0, in good agreement with earlier determinations. The ratio $L_{peat}/L_{water}$ for a Po–Be source was found experimentally to be 1.75. This means that water is 1.75 times better as a medium for stopping neutrons than peat with the same density. It was concluded that the physical analysis of the process for slowing down neutrons shows that the neutron method is applicable for the determination of the moisture content of peat. (TTT)

**10560** AN ACCELERATED METHOD OF DETERMINING THE AIR POLUTION BY DAUGHTER PRODUCTS OF RADON IN MEDICAL INSTITUTIONS. I. I. Gusarov and V. K. Lyapidevskii (Central Scientific-Research Inst. of Physiotherapy and State Research Inst. of Roentgen-Radiology, Ministry of Public Health, USSR). Med. Radiol., 7: No. 12, 63-7(Dec. 1962). (In Russian)

An accelerated technique for the determination of pollution of air by daughter products of radon in medical institutions is described. (P.C.H.)

**10561** COLORIMETRIC DETERMINATION OF THORIUM IN THORIATED TUNGSTEN BY USE OF THORON. George Norwitz (Pitman-Dunn Labs., Philadelphia). Metallurgia, 66: 297-9(Dec. 1962).

A method was developed for the colorimetric determination of Th in thoriated W. The sample is treated with a mixture of hydrofluoric and nitric acids, and the solution is evaporated to dryness. The residue is fused with potassium bisulfate, one ammoniacal precipitation is made, the thorium hydroxide is dissolved in a mixture of sodium tartrate and hydrochloric acid, and the Th is determined by the reagent thoron. (auth)

**10562** DETERMINATION OF CONTAMINATIONS IN PURE PHOSPHORUS BY MEANS OF NEUTRON ACTIVATION USING γ-RAY SPECTROMETRY. Ju. W. Jakowlew and S. Sterlinski. Nukleonika, 7: 141-51(1962). (In Russian)

Arsenic, Mn, and Ga contaminations in spectrally pure and "extra pure" were determined. Phosphorus samples and suitable standards were irradiated by thermal neutrons and analyzed by means of a γ scintillation spectrometer. The arsenic content was determined by direct comparison of the photopeak areas (550 ÷ 650 kev) of P samples and standards. The manganese content in spectrally pure P and the upper level of the Mn content in extra pure P as well as the Ga contents in both sorts of P were determined using the addition extrapolation method. (auth)

**10563** APPLICATION OF THE GUTZEIT METHOD TO RADIOCHEMICAL DETERMINATION OF ARSENIC. PART I. DETERMINATION OF ARSENIC IN ZINC "FREE FROM ARSENIC." Aleksandra Foldzinska and Jerzy Malinowski (Inst. of Nuclear Research, Polish Academy of Sciences, Warsaw). Nukleonika, 7: 153-60(1962). (In English)

A method for the radiochemical separation of As was developed by taking advantage of the reduction of As to arsine with the aid of the Gutzeit method. The efficiency of the Gutzeit method amounts to 90%. In order to evaluate the precision of the method, statistical calculations were performed, and it was found that the error in determining the activity of As amounts to approximately 10%. (auth)

**10564** DETERMINATION OF LEAD CONTENT IN ORE SAMPLES BY MEANS OF THE METHOD OF ABSORPTION OF γ OR X-RAYS. Bohdan Dziunikowski, Tadeusz Florkowski, Leopold Jurkiewicz, and Boguslawa Turkowa (Inst. of Nuclear Techniques, Academy of Mining and Metallurgy, Krakow). Nukleonika, 7: 561-72(1962). (In English)

A method for the quick determination of Pb content in samples of the Zn–Pb ores or of their flotation liquid is presented. The absorption of soft γ and x rays (from β-x sources) is used. The theoretical basis of the method is given as well as the description and results of experiments made to find the optimal conditions of measurements. The accuracy of the method for different systems of the radiation detection and for different ranges of the Pb concentration, is discussed. (auth)

**10565** γ-RAY SPECTROMETRIC DETERMINATION OF TRACE AMOUNT OF CESIUM IN SODIUM AND POTASSIUM SALTS (ON BASIS OF THE ACTIVITY OF $Cs^{134}$, HALF LIFE OF 2.07 YEAR). Slawomir Sterliński and Jerzy Malinowski (Inst. of Nuclear Research, Polish Academy of Sciences, Warsaw). Nukleonika, 7: 693-702(1962). (In Polish)

The possibility of determining cesium traces in sodium and potassium salts by measurement of activity of $Cs^{134}$ with a multi-channel γ spectrometer was confirmed. $2 \times 10^{-3}$ ppm Cs was found as the limit of determination. (auth)

**10566** A SIMPLIFIED WAY OF DETERMINING DEUTERIUM IN WATER BY THE FALLING-DROP METHOD. Ignacy Zlotowski and Maria Wroblewska (Univ. of Warsaw). Nukleonika, 7: 775-88(1962). (In Polish)

A simplified way of applying the falling-drop method is investigated that eliminates the time-consuming determination of the calibration curves. It is shown that an empirical equation can be used that describes the rate of fall of the drop of heavy water falling through the medium of the fluid

measuring mixture, obviating the necessity for determination of calibration curves. (auth)

**10567** PHOTOIONIZATION AND ITS APPLICATION IN ANALYTICAL MASS SPECTROSCOPY. F. I. Vilesov and M. E. Akopyan (Leningrad State Univ.). Pribory I Tekhn. Eksperim., No. 5, 145-8(Sept.-Oct. 1962). (In Russian)

Theoretical and experimental data are offered on the advantages of photoionization as an ion source in the mass spectrometric analysis of complex organic analysis. Less interference from fragment peaks, as compared with electron shock ionization, is demonstrated. (tr-auth)

**10568** DIAMMONIUM-5, 5′-INDIGO DISULPHONATE AS A REAGENT FOR THE GRAVIMETRIC DETERMINATION OF LANTHANUM, GADOLINIUM, AND YTTRIUM. B. D. Jain and J. J. Singh (Univ. of Delhi). Proc. Indian Acad. Sci., Sect. A, 56: 269-73(Nov. 1962).

Lanthanum, gadolinium, and yttrium are quantitatively precipitated by diammonium-5, 5′-indigo disulphonate between pH 3.0 and 7.5 and the resulting complexes on ignition give the corresponding oxide, which can be weighed. Quantities as little as 4.75 mg of $La_2O_3$, 3.3 mg of $Gd_2O_3$, and 4.2 mg of $Yt_2O_3$ can be thus determined. (auth)

**10569** A POLAROGRAPHIC METHOD FOR THE DETERMINATION OF YIELD OF γ-RAY-INDUCED OXIDATION OF Fe(II). Niro Matsuura, Yoshimi Kurimura, and Masao Takizawa. Radioisotopes (Tokyo), 11: 173-8[1962]. (In Japanese)

Solute concentration variations of the γ-induced oxidation of Fe(II) in a 0.8 N $H_2SO_4$ solution by means of the polarographic method are described. Ten ml of the Fe(II) solution in a polarographic cell with a dropping electrode were irradiated under a $N_2$-saturated atmosphere at the rate of $1.92 \times 10^4$ r/hr from an 800-c $Co^{60}$ source in the range of 20 to 30 cm at 25°C. The formations of G(Fe(III)) obtained were 7.4 and 7.5 at 23.5 and 30 cm, respectively. The values were of the same order of magnitude as those obtained by means of the colorimetric method commonly used in iron-dosimetry. Hence, the polarographic method can possibly be used in dosimetry. (OID)

**10570** THE USE OF $Po^{210}$ ALPHA RADIATION FOR THE QUANTITATIVE CONTROL OF CONCENTRATION PRODUCTS CONTAINING BERYLLIUM, BORON, FLUORINE AND ALUMINUM. I. N. Plaksin, V. N. Smirnov, and M. P. Starchik. Tr. Tashkentsk. Konf. po Mirnomu Ispol'z. At. Energ., Akad. Nauk Uz. SSR, 2: 193-299(1960).

Two methods of analysis with the aid of $Po^{210}$ α-radiation, namely, analysis using radiation emitted as a result of the reaction of capturing nuclear particles by reaction (α,n) and activation analysis are discussed. To determine Be, B, and F in concentration products, the following nuclear reactions are employed: $Be_4^9 + He_2^4 \rightarrow C_6^{12} + n_0^1$; $F_9^{19} + He_2^4 \rightarrow Na_{11}^{22} + n_0^1$, and $B_5^{11} + He_2^4 \rightarrow N_7^{14} + n_0^1$. The amount of n is proportional to the Be, F, and B content. To carry out an analysis of powdery products a special device was developed. A detailed layout of the device is presented. The Be, B, and F content is determined from graduation graphs or by a corresponding calculation formula. Radioactivation analysis was employed for the quantitative control of products containing Al and B. $Po^{210}$ with 120 mC activity was employed as a radiation source. The radioactivity induced was measured with an end-window counter. The content is calculated from graduation graphs and plotted for standard mixtures. The separate determination of B and Al is obtained on account of the difference in their maximum radiation energies and the half life periods. The accuracy of determination is 2 to 3%. (Referativnyy zhurnal. Metallurgiya, No. 10, 1961)

**10571** LIMITS OF DETERMINATION FOR SMALL AND THE SMALLEST IMPURITIES IN PURE ALUMINUM AND RAFFINAL USING X-RAY SPECTROSCOPY. Hans Ginsberg and Heimar Pfundt (Vereinigte Aluminum-Werke A. G., Bonn). Z. Metallk., 53: 695-7(Oct. 1962). (In German)

The limits of determination of zinc, copper, iron, manganese, vanadium, and titanium in aluminum were determined by means of x-ray spectroscopy. This method as well as the common analysis by wet process was proved to be useful within the range of 0.1 to 0.0001 wt%, and therefore, the two methods can be considered equivalent as to the final results. (auth)

**10572** DETERMINATION OF Eu IN RARE EARTH OXIDES BY SQUARE-WAVE POLOROGRAPHY. B. Ya. Kaplan and I. A. Sorokovskaya (State Scientific-Research and Design Inst. of Rare Metal Industry, USSR). Zavodsk. Lab., 28: 1424-7(1962). (In Russian)

Polarographic determination of Eu in rare earth oxides was carried out in the presence of trilone B at pH = 8 to 10, using unitiol separation of lead from the rare earths. The sensitivity for Eu in samarium oxide is 0.003% and in neodymium, 0.001%. (R.V.J.)

**10573** DETERMINATION OF GOLD BY MEANS OF RADIOACTIVATION. A. A. Lbov and I. I. Naumov. Zavodsk. Lab., 28: 1475-7(1962). (In Russian)

Activation analysis was used to determine microquantities of Au in silicate minerals. The $Au^{198}$ γ activity was measured without preliminary radiochemical refining. The sensitivity of the method was wt $10^{-5}$%. (R.V.J.)

**10574** DETERMINATION OF GERMANIUM IN MINERAL SPECIMENS BY NEUTRON ACTIVATION ANALYSIS. M. A. Wahlgren and K. A. Orlandini (Argonne National Lab., Ill.). Oct. 1962. Contract [W-31-109-eng-38]. 13p. (UAC-6933; UAC-7010). (TID-17665)(ORINS)

To be published in TID-7655, Proceedings of the 6th Symposium on Analytical Chemistry in Nuclear Reactor Technology, Gatlinburg, Tenn., Oct. 9-11, 1962.

Neutron activation analysis was applied to the determination of germanium in quartz samples. The radiochemical procedures used in the analysis are described. (D.L.C.)

**10575** ZUR ANALYTISCHEN CHEMIE IN ALKALINITRATSCHMELZEN. (Analytical Chemistry in Alkali Metal Nitrate Melts). Karl Poetzl. Thesis, Munich, Universität, 1962. 103p.

The use of salt melts as reaction media for analytical separations is discussed. Advantages in the use of molten salts compared with aqueous systems are outlined. Materials for use with alkali metal nitrate melts were tested. Platinum, porcelain, quartz, and Jena glass proved to be satisfactory. Temperature regulation devices containing photocells were designed. A filtering column that could be heated and regulated was developed for filtering the molten salts. Systematic investigations were made of the behavior of elements in the alkali metal nitrate melt. Results are discussed and presented in tables. The determination of alkaline earths in silicates and the separation of Fe-Ni, Sn-Rb, and Pb-Si are described. An analytical method making use of separation in salt melts was developed for determination of fission products from fallout in glacier residue, plant ashes, and animal organs. (M.C.G.)

## Inorganic and Physical Chemistry

**10576** (AE-96) ISOMORPHIC SUBSTITUTIONS OF CALCIUM BY STRONTIUM IN CALCIUM HYDROXYAP-

ATITE. Hans Christensen (Aktiebolaget Atomenergi, Stockholm). Dec. 1962. 9p.

In an investigation concerning the separation of Sr from aqueous solutions, the synthesis of crystalline solid solutions of calcium strontium hydroxyapatite from aqueous systems was effected. Results indicate that the discrimination of Sr against Ca is small and that Sr is preferentially built into the c-axis direction of the apatite lattice. (J.R.D.)

**10577** (ANL-FGF-292) THE RATE OF SOLUTION OF SOME TRANSITION ELEMENTS IN LIQUID ALUMINUM. J. B. Darby, Jr., D. B. Jugle, and O. J. Kleppa (Argonne National Lab., Ill.). Apr. 2, 1962. Contract [W-31-109-eng-38]. 22p. (UAC-6340)

A systematic study was made of the kinetics of solution under steady-state dynamic conditions of titanium, vanadium, chromium, iron, cobalt, and nickel in liquid aluminum. It was found that the temperature dependence of the solution rate obeyed an Arrhenius-type rate equation, and that at a given temperature the rate of solution of the various solutes correlates quantitatively with the equilibrium solubility of the solute in liquid aluminum. These results are consistent with a mechanism where the rate-controlling step is the diffusion of solute atoms through a liquid boundary layer. (auth)

**10578** (ANL-FGF-332) NEUTRON AND X-RAY DIFFRACTION STUDIES ON NONSTOICHIOMETRIC METAL HYDRIDES. S. S. Sidhu, N. S. Satya Murthy, F. P. Campos, and D. D. Zauberis (Argonne National Lab., Ill.). Mar. 14, 1962. Contract [W-31-109-eng-38]. 26p. (UAC-6209)

A diffraction study using neutrons and x rays was made of metal hydride systems in which the metal-rich regions are emphasized. The composition range used was 2 to 66.5 at. % $H_2$ in Hf, Ti, and Zr; and a system consisting of 62 at. % Ti and 38 at. % Zr. The samples studied were in the form of deuterides. Results of the investigation show that the Zr–D system has $\alpha$, $\gamma$, $\sigma$, and $\epsilon$ phases as in the H systems. Differences between the Zr–H and Zr–D systems are discussed. (J.R.D.)

**10579** (ASD-TDR-62-873) LITERATURE SURVEY ON SYNTHESIS, PROPERTIES, AND APPLICATIONS OF SELECTED BORIDE COMPOUNDS. Barry R. Emrich (Aeronautical Systems Div. Applications Lab., Wright-Patterson AFB, Ohio). Aug. 1962. 122p.

A comprehensive review of the literature was made to assist in providing background information needed for future work concerning boride materials. The materials reviewed included solid bodies of $TiB_2$, $ZrB_2$, $HfB_2$, $VB_2$, $NbB_2$, $TaB_2$, $CrB_2$, and $ThB_4$. Information is presented on synthesis, properties, and applications of the selected boride compounds, including selected abstracts and articles. Results of the search indicate the need for the development of authoritative scientific information on borides applicable to future technological requirements. (auth)

**10580** (BM-RI-6155) THERMODYNAMIC PROPERTIES OF YTTRIUM METAL AND IRON PENTACARBONYL AT HIGH TEMPERATURES. James R. Welty, Charles E. Wicks, and Herbert O. Boren (Bureau of Mines. Albany Metallurgy Research Center, Ore.). June 1962. 12p.

Heat content values were experimentally determined for yttrium metal between temperatures of 400 and 1,300°K and for iron pentacarbonyl between 301 and 380°K. The drop technique was used, that is, a sample of material sealed in a protective capsule was heated to a desired temperature in a furnace and then dropped into an ice calorimeter. A revised technique for determining heat content values from calorimetric data is described. Heat content and corresponding entropy-increment data above a reference temperature of 298.15°K are presented in tabular form. Equations for heat content and heat capacity as functions of temperature were derived for each substance. (auth)

**10581** (BNL-639) DISTRIBUTION OF URANIUM AND CERIUM BETWEEN LIQUID BISMUTH–MAGNESIUM ALLOY AND LIQUID NaCl–KCl–$MgCl_2$ EUTECTIC. F. J. Salzano and F. B. Hill (Brookhaven National Lab., Upton, N. Y.). June 1962. 19p. (BNL-T-201).

The distributions of U and Ce between dilute solutions of Mg in Bi and the eutectic mixture of NaCl, KCl, and $MgCl_2$ were measured at 500°C on a kilogram scale in metallic containers. The dependence of the distribution coefficients for Ce on the concentration of Mg in Bi was found to be reproducible and consistent with the stoichiometry of a reversible exchange reaction between the distributing solute and Mg. The coefficients for U behaved similarly but were not as reproducible. The observed average separation factor between Ce and U was 420. A conservative value is 100. No effects of using two methods of salt preparation, two container materials, and two salt/Bi volume ratios were clearly discernible. A partially reversible loss of U was observed which was attributed to the presence of impurities in the salt. (auth)

**10582** (HW-SA-1973) ACTIVE METAL REDUCTION OF PLUTONIUM TRICHLORIDE. T. S. Soine and H. H. Hopkins, Jr. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 6, 1960. Contract [AT(45-1)-1350]. 9p.

The reduction characteristics of plutonium trichloride are investigated. A flowsheet for batch reduction with Ca is included. (J.R.D.)

**10583** (HW-SA-2452) EFFECT OF BASE CATION ON THE CESIUM KINETICS OF CLINOPTILOLITE. L. L. Ames, Jr. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Feb. 1962. Contract AT(45-1)-1350. 10p.

The Cs exchange kinetics of Li, Na, K, $H_2$, Ca, and Ba-based clinoptilolite samples were determined by a "shallow bed" in the film and particle diffusion regions. Results showed Cs exchange for Li on the clinoptilolite to be the most rapid, and $H_2$ exchange to be among the slowest reactions. The hydrated cation replacement series exhibited by clinoptilolite is the probable cause of the resulting cesium exchange kinetics. (auth)

**10584** (BM-RI-6157) THERMODYNAMIC PROPERTIES OF CESIUM CHLORIDE AND CESIUM IODIDE FROM 0° TO 300°K. A. R. Taylor, Jr., T. Estelle Gardner, and D. F. Smith (Bureau of Mines. Tuscaloosa Metallurgy Research Center, Ala.). June 1962. 10p.

Low-temperature heat capacities of cesium chloride (7 to 300°K) and cesium iodide (13 to 300°K) were measured with an adiabatic calorimeter. The heat-capacity measurements were analyzed graphically to determine smooth values of heat capacity, entropy, enthalpy function, and free-energy function at 10°K intervals and at 273.15° and 298.15°K. (auth)

**10585** (HW-SA-2596) ANION EXCHANGE AND NON-AQUEOUS STUDIES OF THE ANIONIC CHLORO COMPLEXES OF THE HEXAVALENT ACTINIDES. J. L. Ryan (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). [May 21, 1962]. Contract [AT (45-1)-1350]. 34p.

Spectrophotometric studies of anion-exchange resins of solid crystalline salts and of non-aqueous solutions were used to identify the hexavalent actinide chloride species

absorbed by anion-exchange resins and those extracted by liquid alkylammonium extractants. The actinide(VI) tetrachloro complexes were found to undergo hydrogen bond formation with hydronium ion, hydrogen chloride, and tertiary, secondary, and primary alkylammonium ions. The species absorbed by anion exchange resins appear to be $[H_3O(H_2O)_3(MO_2Cl_4)_2]^{3-}$ from aqueous solutions and $MO_2Cl_4^{2-}$ from alcohol solutions. The species present in the organic phase in solvent extraction by tertiary alkylamines are the tetrachloro complexes hydrogen bonded to the alkylammonium ions. In extraction by liquid quaternary alkylammonium extractants, the species in the organic phase are the simple $MO_2Cl_4^{2-}$ ions. The only effect of this hydrogen bonding on the visible and near visible absorption spectra of the actinide(VI) tetrachloro complexes is to change the relative peak intensities of the symmetrical metal–oxygen vibrational spectra. (auth)

**10586** (HW-SA-2597) THERMODYNAMIC EVIDENCE FOR COMPLEX FORMATION BY ACTINIDE ELEMENTS IN FUSED $KCl-AlCl_3$ SOLVENTS. J. R. Morrey and R. H. Moore (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). [May 21, 1962]. Contract AT(45-1)-1350. 15p.

Previously reported experimental measurements of the equilibrium $UCl_3(l) + Al(l) \rightleftharpoons \frac{1}{2}\ Al_2Cl_6\ (g)$, which was carried out in the solvent $KCl-AlCl_3$, were explained by a model involving the complex ions $Al_2Cl_7^-$, $AlCl_4^-$, and $UCl_6^{3-}$. Calculations made by a high speed computer proved the sufficiency of the model and provided the appropriate formation constants. Models involving anionic complexes other than $UCl_6^{3-}$ were rejected because they could not adequately reproduce the data. Analysis of less complete data for the reduction of thorium, protactinium, neptunium, and plutonium chlorides shows that a model involving the same aluminum species and complex actinide species describes the experimental results. (auth)

**10587** (HW-SA-2621) THE IMMISCIBILITY GAP IN THE SYSTEM: $LiCl-KCl-AlCl_3$. R. H. Moore (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). [June 4, 1962]. Contract AT(45-1)-1350. 15p.

The system $LiCl-KCl-AlCl_3$ was found to exhibit an immiscibility gap extending over a temperature range of from 350 to 775°C. The composition extent of the binodal surface was defined by isothermic-isobaric sections at 450, 525, 625, 715, and 770°C. The cause of immiscibility is discussed in qualitative terms. (auth)

**10588** (IA-764) ANION EXCHANGE OF METAL COMPLEXES. VIII. THE EFFECT OF THE SECONDARY CATION. THE ZINC–CHLORIDE SYSTEM. Y. Marcus and Daliah Maydan (Israel. Atomic Energy Commission, Rehovoth). Sept. 1962. 23p.

Distribution measurements were made of tracer radioactive zinc ions between Dowex-1 quaternary ammonium anion exchange resin, crosslinked by various amounts (2, 4, 8, 10, and 16%) of divinyl benzene, and aqueous solutions of chlorides of lithium, sodium, ammonium, potassium, and cesium and hydrochloric acid. The invasion of the various electrolytes into the resins was also measured. Expressing the electrolyte concentrations in terms of activity functions $a = m\gamma_\pm$ and correcting the distribution coefficients for the electrolyte invasion yielded parallel curves for the various crosslinked resins. These may be described by a single set of complex formation parameters for the aqueous solutions, the same set for all alkali metal chlorides, and one parameter dependent on the crosslinking. (auth)

**10589** (IS-481) SOLUTIONS OF GALLIUM(I) SALTS IN AQUEOUS BASE. John D. Corbett (Ames Lab., Ames, Iowa). [June 7, 1962]. Contract [W-7405-eng-82]. 12p.

The chemistry of gallium(I) in basic solutions was studied. The kinetics of the reaction of $Ga(GaCl_4)$ with NaOH solution were measured by following the rate of $H_2$ evolution, and the reaction $Ga^+ + 2H_2O + 2OH^- \rightarrow Ga(OH)_4^- + H_2$ was found to be first order in both $Ga^+$ and $OH^-$. Neutralization of the basic solutions resulted in a white precipitate resembling $Ga_2O_3$. The reducing reactions of basic solutions of $Ga(GaCl_4)$ were studied. The potential of $Ga-Ga^{3+}$ was estimated to have a lower limit of ~0.40 v and the potential for $Ga-Ga^+$ to have a maximum of ~0.79 v in acid solution. The disproportionation of $Ga^+$ is discussed. (D.L.C.)

**10590** (IS-487) THE PREPARATION AND PROPERTIES OF MOLYBDENUM(IV) BROMIDE. P. J. H. Carnell and R. E. McCarley (Ames Lab., Ames, Iowa). [June 12, 1962]. Contract [W-7405-eng-82]. 15p.

The preparation of pure $MoBr_4$ was accomplished conveniently by the reaction between $MoBr_3$ and liquid $Br_2$ at ~55°C. $MoBr_4$ was found to be soluble in liquid $Br_2$, and this property was utilized to separate and purify the $MoBr_4$. The solution of $MoBr_4$ in $Br_2$ was a poor electrical conductor. No evidence was found for the formation of $MoBr_4$ from $MoBr_3$ and $Br_2$ vapor at 2 to 4 atm. and 180 to 400°C. However, $MoBr_4$ was completely decomposed at 110 to 130°C, in vacuo, with formation of $MoBr_3$ and $Br_2$. (auth)

**10591** (IS-499) THE HYDROLYSIS OF THE RARE-EARTH CARBIDES. Harry J. Svec, Jennings Cappellen, and Fred E. Saalfeld (Ames Lab., Ames, Iowa). [July 2, 1962]. Contract [W-7405-eng-82]. 17p.

The hydrolysis of rare-earth dicarbides, sesquicarbides, solid solutions of C in rare-earth metals, and rare-earth-carbon systems of varying compositions was studied. Experimental methods and results are given. (J.R.D.)

**10592** (IS-520) CATALOG OF NUCLEAR QUADRUPOLE INTERACTIONS AND RESONANCE FREQUENCIES IN SOLIDS. PART I. ELEMENTS AND INORGANIC COMPOUNDS. S. L. Segel and R. G. Barnes (Ames Lab., Ames, Iowa). Oct. 1962. Contract W-7405-eng-82. 69p.

A tabulation of nuclear quadrupole resonance data is provided giving the quadrupole resonance frequency for a given nucleus in a given compound, and, where reported in literature, the coupling constant. Data are given for Al, Sb, As, Ba, Be, Bi, B, Cs, Cu, D, Ga, In, Li, Hg, Nb, N, Re, Rb, Na, S, Tc, Cl, Br, I, chlorides, bromides, iodides, chlorates, bromates, and iodates. (M.C.G.)

**10593** (LA-2813) THERMODYNAMIC FUNCTIONS FOR PURE PLUTONIUM. Robert N. R. Mulford (Los Alamos Scientific Lab., N. Mex.). Nov. 1962. Contract W-7405-eng-36. 11p.

Values for heat capacity, enthalpy and entropy increments, free energy function, vapor pressure, and heat and entropy of vaporization for solid and liquid plutonium at temperatures from 298.16 to 2500°K are tabulated. Heats of transition are also included. (auth)

**10594** (TID-15741) ASSOCIATION CONSTANTS OF CADMIUM ION AND CHLORIDE ION IN CONCENTRATED AQUEOUS SOLUTIONS OF AMMONIUM NITRATE. J. Braunstein and J. M. C. Hess (Maine. Univ., Orono). [1962]. Contract [AT(30-1)-2873]. 14p.

Electrochemical force measurements were made in dilute solutions of $Cd(NO_3)_2$ and $NH_4Cl$ in concentrated aqueous solutions (up to 11 M) of $NH_4NO_3$ at 39.93°C. The

activity coefficients for both $Cd(NO_3)_2$ and $NH_4Cl$ were calculated from the data and found self-consistent with each other. The association constant for the formation of CdCl was calculated and is tabulated in several different concentration units for three different $H_2O/NH_4NO_3$ ratios. (D.L.C.)

**10595** (TID-15770) VAPOR-LIQUID EQUILIBRIUM IN THE SYSTEM BROMINE PENTAFLUORIDE–URANIUM HEXAFLUORIDE. Robert C. Liimatainen (Argonne National Lab., Ill.) and Bernet S. Swanson (Illinois. Inst. of Tech., Chicago). Mar. 12, 1962. Contract [W-31-109-eng-38]. 21p. (UAC-6227)

In order to make equilibrium studies on $BrF_5$–$UF_6$ systems, an equilibrium still capable of handling halogen materials was designed and built. It was established that the vapor pressure of $BrF_5$ at temperatures above its boiling point is correctly given by the equation of Long et al. where $\log_{10}P_1^0 = 6.4545 + 0.001101t - 895/(t + 206)$ with t = °C and $P_1^0$ = mm Hg. The compressibility factors of saturated vapor mixtures of $BrF_5$ and $UF_6$ were 0.936 and 0.917 at 70 and 90°C, respectively. These values were in agreement with predictions from equations of state. The binary vapor-liquid equilibrium in the system showed positive deviations from ideality with no azeotrope. (M.C.G.)

**10596** (TID-15793) MECHANISMS OF ONE-ELECTRON REDOX REACTIONS INVOLVING DESTRUCTION OF THE $MO_2^+$ STRUCTURE. J. C. Sullivan and E. H. Appelman (Argonne National Lab., Ill.). Mar. 1962. Contract [W-31-109-eng-38]. 9p. (UAC-6267)

The one-electron reduction of Np(V) may be represented as $[O-Np-O-(H_2O)_2]^+ + e^- + 4H \rightarrow [Np-(H_2O)_4]^{4+}$. Possible mechanisms for the one-electron reduction of Np(V) by Fe(II), Np(III), and V(III) are discussed. Evidence is presented for the intermediate reaction $Np(V) + H^+ \rightarrow [Np(V) \cdot H^+]$. Tables of rate laws are given for these reductions. (D.L.C.)

**10597** (TID-15795) THERMODYNAMIC PROPERTIES OF $ZrH_2$, $ZrD_2$, $YH_2$, AND $YD_2$. Howard E. Flotow and Darrell W. Osborne (Argonne National Lab., Ill.). Mar. 1962. Contract [W-31-109-eng-38]. 29p. (UAC-6256)

The heat capacities of the dihydrides and dideuterides of zirconium and of yttrium were measured by means of an adiabatic calorimeter in the temperature range 5 to 350°K. The entropy $S^0$, enthalpy increment $H^0 - H_0^0$, and Gibbs free-energy function $(G^0 - H_0^0)/T$ were evaluated from the heat capacity data and are tabulated at selected temperatures. The following values were obtained for the heat capacity at constant pressure, for the entropy, for the enthalpy increment, and for the Gibbs free energy function, respectively, at 298.15°K: for $ZrH_2$, 7.396 ± 0.015 cal $deg^{-1}$ $mole^{-1}$, 8.374 ± 0.02 cal $deg^{-1}$ $mole^{-1}$, 1284.1 ± 2 cal $mole^{-1}$, and – 4.067 ± 0.01 cal $deg^{-1}$ $mole^{-1}$; for $ZrD_2$, 9.631 ± 0.019, 9.168 ± 0.02, 1474.4 ± 3, and – 4.233 ± 0.01; for $YH_2$, 8.243 ± 0.016, 9.175 ± 0.018, 1402.7 ± 3, and – 4.470 ± 0.009; for $YD_2$, 10.773 ± 0.022, 10.294 ± 0.021, 1659.1 ± 3, and – 4.729 ± 0.010. From an analysis of the heat capacity curves it is deduced that the hydrogen vibration frequency is 1180 ± 30 $cm^{-1}$ in $ZrH_2$ and 1030 ± 30 $cm^{-1}$ in $YH_2$, in satisfactory agreement with neutron scattering experiments. Other thermodynamic properties of these hydrides, including recent measurements of the heats of combustion of $ZrH_2$ and $ZrD_2$, are discussed briefly. (auth)

**10598** (TID-15796) VAPORIZATION AND THERMODYNAMIC PROPERTIES OF URANIUM SULFIDE AND OXYSULFIDE. E. David Cater, E. G. Rauh, and R. J. Thorn (Argonne National Lab., Ill.). Mar. 1962. Contract [W-31-109-eng-38]. 20p. (UAC-6252)

A review is presented on the vaporization properties of uranium sulfides. The vaporization behavior of US is described in detail, and the behavior of the U–S system is compared with that of the U–O system at atom ratios near unity. Some of the aspects of the vaporization behavior in the U–S–O system are described. Comments are given on the chemical bonding in gaseous oxides and sulfides. (D.L.C.)

**10599** (TID-15935) MAGNETIC CHARACTERISTICS OF HYDROGENATED HOLMIUM. Y. Kubota and W. E. Wallace (Pittsburgh. Univ.). [196?]. Contract AT(30-1)-647. 7p.

Since coupling of the lanthanides occurs via the conduction electrons, hydrogenation should lead to very considerable suppression of the interactions in the hydrides compared to the element, but an unchanged effective atomic moment. To determine whether this is the case susceptibility measurements were made on a series of nine Ho–H systems. These showed for the dihydride, which still contains some conduction electrons, a Néel point at around 8°K (instead of 135°K for the element), whereas for the trihydride, which lacks conduction electrons, no Néel point was observed down to 4°K. Susceptibilities of the hydrides above about 15°K obeyed the Curie-Weiss law with a much smaller Weiss constant than that for elemental holmium. The atomic moment was found, however, to be virtually unaffected by hydrogenation. (auth)

**10600** (TID-15939) COMPUTER ANALYSIS OF POTENTIOMETRIC AND SOLVENT EXTRACTION STUDIES OF THE FLUORIDE COMPLEXES OF HAFNIUM. Louis P. Varga and David N. Hume (Oklahoma State Univ., Stillwater; Massachusetts Inst. of Tech., Cambridge. Dept. of Chemistry; and Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). [June 13, 1962]. Contract [AT(30-1)-905]. 29p.

Measurements on fluoride-containing hafnium solutions in 3M perchlorate media at 25°C by precision potentiometry and by solvent extraction distribution using thenoyltrifluoroacetone (TTA) and tri-n-octylphosphine oxide (TOPO) were subjected to high-speed digital computer analysis and the results interpreted in terms of the nature and stabilities of complex hafnium fluoride species present. Potentiometric hydrogen ion measurements with a quinhydrone half-cell gave the formation function for the mononuclear series of hafnium fluoride complexes from an average ligand number of about 2 to a maximum value of about 6. At radioactive trace concentrations of hafnium, TTA extracted only $Hf^{4+}$, giving useful information on the formation of the first four fluoride complexes. TOPO extracted two species, one containing two fluoride ions per hafnium ion and the other none, and the data were interpretable in terms of five aqueous-phase species including $HfF_5^-$. The TTA and potentiometric data were combined in a weighted, non-linear regression machine program to calculate simultaneously the stepwise formation constants of the first six mononuclear fluoride complexes of hafnium. The values obtained were $\log k_1 = 4.89$, $\log k_2 = 3.67$, $\log k_3 = 2.97$, $\log k_4 = 2.77$, $\log k_5 = 1.55$, and $\log k_6 = 2.54$, where $k_n = (HfF_n)\,(H^+)/(HfF_{n-1})\,(HF)$. (auth)

**10601** (TID-15942) KINETICS OF FAST INTERFACIAL REACTIONS WITH PARTICULAR REFERENCE TO A TECHNIQUE FOR STUDY OF METAL CORROSION. Chatten Cowherd, Jr., and H. E. Hoelscher (Johns Hopkins Univ., Baltimore). Apr. 1962. Contract AT(30-1)-2334. 37p.

An analysis is presented of the problems associated with the study of the kinetics and mechanism of fast interfacial chemical reactions. It is difficult to obtain meaningful kinetic information from such systems because of the intruding influence of the diffusional processes and their heretofore almost inevitable influence on the data and conclusions from such studies. Such difficulties have hindered progress toward an understanding of metal corrosion and other similar processes. A detailed scheme for the analysis of suitable experimental data to yield the kinetics of the surface reaction is presented. An experimental program designed to test this analytical procedure is described. Some results from this study are presented. It is concluded that the proposed technique does permit the determination of the kinetics of the surface reaction divorced from the effects of molecular diffusion. (auth)

**10602** (TID-16820) HIGH TEMPERATURE OXIDATION AND NITRIDATION OF NIOBIUM IN ULTRAHIGH VACUUM. Quarterly Report No. I, Covering the Period June 1 to August 31, 1962. R. A. Pasternak (Stanford Research Inst., Menlo Park, Calif.). Sept. 13, 1962. Contract AT(04-3)-115. 17p.

A theoretical treatment was carried out to predict sorption rates on the basis of existing data. The three steps of the sorption process (adsorption on surface, transfer across the surface-bulk interphase, and diffusion in the bulk) are discussed and their interrelation studied. An experimental ultrahigh vacuum system was developed for the experimental studies. (D.L.C.)

**10603** (TID-17721) PROPERTIES OF $He^3$ AT PRESSURES GREATER THAN THE MINIMUM IN THE MELTING CURVE. A. C. Anderson, W. Reese, and J. C. Wheatley (Illinois. Univ., Urbana). [1962]. Contract [AT(11-1)-1198]. 41p.

Measurements of the specific heat and velocity of sound in $He^3$ as functions of pressure and temperature were obtained for temperatures from 0.02 to 0.3°K and pressures greater than the minimum in the melting curve. These measurements indicate that only two phases, liquid and $\alpha$-solid, exist in this region of the phase diagram. The melting curve was measured to 0.03°K. The thermodynamic consistency of the data is discussed in terms of a two phase model. The data are compared with predictions which assume the solid entropy to be R ln2, and qualitative agreement is obtained. Additional evidence from magnetic measurements is given in support of the two phase description. (auth)

**10604** (TID-17724) STUDIES OF $H_2^+$ DISSOCIATION. Interim Annual Report No. 2. A. W. Ehler (Hughes Research Labs. Div. of Hughes Aircraft Co., Malibu, Calif.). Jan. 12, 1963. Contract AT(04-3)-362. 9p.

Results of a series of experiments on $H_2^+$ dissociation indicated that the dissociation ratio observed at the lowest pressure is due to electric field dissociation only. After these experiments were run, the dissociation ratio was remeasured for one electric field value for comparison with previous results. With the differential pumpout connected and the device operated at its lowest pressure, a dissociation ratio of 0.0034 with a standard deviation of 0.0002 at an electric field of 103,000 v/cm was obtained for 18 measurements. This value agreed with the value previously reported. (auth)

**10605** (TID-17816) TECHNICAL PROGRESS REPORT [ON METAL IONS DISSOLVED IN INORGANIC SALTS]. (Temple Univ., Philadelphia). Jan. 1963. Contract AT(30-1)-2780. 78p.

Transition metal ions dissolved in low-melting inorganic salts in the presence of various complexing agents were studied. The solvents used in the investigations are $LiNO_3-KNO_3$ eutectic, $NaNO_3-KNO_3$ eutectic, and pure $KNO_3$. Results are included on the conductivity of Co(II) solutions in the solvents in the presence of bromide, chloride, and fluoride ions. Similar studies involving Ni(II) are in progress. Other work is reported on electromotive force measurements. (J.R.D.)

**10606** (UCRL-7069) HARC AND HEART THROB: COMPUTER PROGRAMS FOR TRANSIENT TEMPERATURE DISTRIBUTIONS AND CHEMICAL REACTIONS IN COMPOSITE SOLIDS. Arthur L. Edwards (California. Univ., Livermore. Lawrence Radiation Lab.). Dec. 11, 1962. Contract W-7405-eng-48. 113p.

The HARC and HEART THROB FORTRAN programs have been developed to solve problems involving transient temperature distributions in one or two dimensions and in simple geometries. The programs are designed to be simple to use, applicable to a wide variety of problems, and economical of machine time. The modes of heat transport and production include internal conduction and radiation between interfaces; specified heat fluxes, temperatures, or heat transfer by convection at surfaces; internal heat generation by two first-order chemical reactions with Arhennius temperature dependence; and a distribution of exponentially decaying heat sources. The geometry may consist of parallel slabs or concentric cylindrical or spherical shells, each with specified properties. A forward-time step-difference equation is used for most points, subject to a stability condition. For specified layers, a calculation method, not subject to a stability condition, may be used; allowing larger time increments to be used in many problems. The size of the time increment is controlled within specified limits by limiting the size of the maximum temperature change in one time increment, thus defining a controlled accuracy with a minimum amount of machine time. The programs have been used successfully for many problems over a period of about two years. Running time for most problems is in the range of 1-15 minutes on the IBM 7090. (auth)

**10607** (UCRL-10189) CALCULATION OF INTEGRAL AND PARTIAL THERMODYNAMIC FUNCTIONS FOR SOLIDS FROM DISSOCIATION PRESSURE DATA. David J. Meschi and Alan W. Searcy (California. Univ., Berkeley. Lawrence Radiation Lab.). Apr. 23, 1962. Contract W-7405-eng-48. 23p.

From dissociation pressure data taken from other papers, calculations are made of enthalpies, entropies, partial molal Gibbs free energies, activities, and activity coefficients for uranium–hydrogen and zirconium–hydrogen systems to show that proper treatment of data yields partial as well as integral thermodynamic functions for solids. Results are given in graphs and tables. (D.C.W.)

**10608** (UCRL-10197) CRYSTAL STRUCTURE OF $KH_2F_3$ AND GEOMETRY OF THE $H_2F_3^-$ ION. J. D. Forrester, Michael E. Senko, Allan Zalkin, and David H. Templeton (California. Univ., Berkeley. Dept. of Chemistry and California. Univ., Berkeley. Lawrence Radiation Lab.). Apr. 30, 1962. Contract W-7405-eng-48. 15p.

Crystals of $KH_2F_3$ were studied by x-ray diffraction. The crystals were found to be orthorhombic and their structure as a whole is salt-like with K ions well dispersed among the $H_2F_3^-$ ions. The shortest K-K distance is 4.34 Å. Each K atom has 8 F atom neighbors, each a member of a different $H_2F_3^-$ ion, at distances averaging 2.83 Å for $K_1$ and 2.82 Å for $K_2$. (J.R.D.)

**10609** (UCRL-10504) ENERGY EXCHANGE BETWEEN COLD GAS MOLECULES AND A HOT TUNGSTEN SURFACE (thesis). Gerald Leroy DePoorter (California. Univ., Berkeley. Lawrence Radiation Lab.). Nov. 12, 1962. Contract W-7405-eng-48. 33p.

The exchange of energy between a tungsten filament heated at 1710 to 2500°K and cold helium, neon, argon, nitrogen, and carbon dioxide was studied. Gas pressures from 0.1 to 10μ Hg were used. The exchange of energy was directly proportional to the gas pressure but was essentially independent of the filament temperature. The results were interpreted in terms of a process in which the impinging gas molecules are first physically adsorbed, then heated until they gain sufficient thermal energy to overcome the attractive forces of the tungsten surface. On the average, the gas molecules then "desorb" at a certain "critical" temperature that is independent of the filament temperature. The critical temperatures for the gases used lie between 350 and 550°K. (auth)

**10610** (UCRL-10575) KINETIC ANALYSIS OF CONSECUTIVE-REACTION MODEL SYSTEMS. Howard R. Siewert, Peter N. Tenney, and Theodore Vermeulen (California. Univ., Berkeley. Lawrence Radiation Lab. and California. Univ., Berkeley). Nov. 30, 1962. Contract W-7405-eng-48. 106p.

Numerical solutions are needed to carry out kinetic calculations of multiple-reaction systems. Two types of consecutive-reaction models are studied here: consecutive-competitive, and consecutive-reversible (with one reversible step). For the consecutive-competitive reaction model, the effect of an excess of either of two reactants on (a) the time for the system to react to a given conversion, and on (b) the relative yields of intermediate and final products is determined. An excess of either reactant is an important design factor, because it may minimize the required reactor volume and maximize the production rate of the desired product. Several different kinds of consecutive-reversible cases are studied. These include cases where all the reaction steps are first-order and cases in which there is at least one second-order step. Except for isolated second-order cases, only the all-first-order cases can be solved analytically. The second-order cases are solved numerically using a fourth-order Runge-Kutta method. In cases which contain a second-order step, the proportions of intermediate and final products are dependent upon the initial reactant concentration regardless of which reaction step is second-order. For plug-flow or batch reactors, the calculational results are presented as graphs or tables of either conversion of dimensionless concentrations as a function of dimensionless time for each model considered. For continuous stirred-tank reactors, graphical results are given for the consecutive-competitive model and for certain consecutive-reversible systems. The graphs and tables are useful both for design and for interpretation of experimental data. The required calculations were done on the IBM 650 and 7090 Computers. (auth)

**10611** (UCRL-Trans-894(L)) STUDY OF THE CONDENSATION OF SODIUM MOLYBDATE UNDER THE ACTION OF NITRIC ACID BY THE CONDUCTOMETRIC METHOD. Raluca Ripan and A. Duca. Translated by Sergey Shewchuck (Univ. of California Lawrence Radiation Lab., Livermore) from Rev. Chim., Acad. Rep. Populaire Roumaine, 2: 73-95(1954). 26p.

Studies were made of the transformations produced when a solution of $MoO_4Na_2$ is treated with $HNO_3$. It was proved that the $MoO_4^{2-}$ condenses, but it was impossible to reveal a continuous series of compounds but only a single form of combustion for the three ratios: ($6Mo:6H^+$), ($6Mo:8H^+$), and ($6Mo:9H^+$). The following condensed molecules were obtained: $[Mo_6O_{21}]Na_6$, $[Mo_6O_{21}]H_2Na_4$, and $[Mo_6O_{21}]H_3Na_3$. It was proved that the molecule $[Mo_6O_{21}]^{6-}$ has the structure $[MoO(MoO_4)_5]$ and that it can be obtained by direct synthesis in solution starting with $[MoO_6]Na_2Ba_2$. (M.C.G.)

**10612** QUENCHING EFFECT OF OXYGEN ON THE LIGHT EMISSION PRODUCED BY DISSOLUTION OF IRRADIATED SODIUM CHLORIDE IN WATER. L. E. Goeran Eriksson (Royal Inst. of Tech., Stockholm). Acta Chem. Scand., 16: 2113-16(1962). (In English)

Light is emitted when irradiated sodium chloride is dissolved in water. It was shown that oxygen was a quencher. Some ideas were put forward about the mechanism by which the stored energy, represented by the structural defects, is released. (auth)

**10613** MEASUREMENTS OF THE SELF-DIFFUSION OF WATER IN PURE WATER, $H_2O-D_2O$ MIXTURES AND SOLUTIONS OF ELECTROLYTES. Lennart Devell (Royal Inst. of Tech., Stockholm). Acta Chem. Scand., 16: 2177-88(1962). (In English)

The self-diffusion of water was measured at 25.0°C in pure water, $H_2O-D_2O$ mixtures, and solutions of NaCl, LiBr, and $MgSO_4$. The diffusion cells used were of the shearing boundary type and are described. Deuterium and tritium were used as tracers. Analysis of deuterium was performed by means of a mass spectrometer. Tritium was detected by means of liquid scintillation technique, or by an improved version of the bremsstrahlung method. Comparative measurements in pure water at 25.0°C with deuterium and tritium as tracers gave identical results ($2.25 \pm 0.02$) $\times 10^{-5}$ $cm^2/sec$) with those obtained from measurements on $H_2O-D_2O$ mixtures using a precision optical method. The result thus indicates that the isotope effect is within experimental error. The self-diffusion of water in $H_2O-D_2O$ mixtures, having tritium as tracer, seems to decrease linearly with the increase in deuterium content. The self-diffusion coefficient in dilute salt solutions was very moderately affected. In concentrated solutions decreasing effects were most pronounced in solutions of $MgSO_4$. A comparison of the inverse viscosity versus solute concentration with the self-diffusion shows a similar course for the two functions. The results in the case of salt solutions are discussed briefly in terms of the theory of Wang. Data of others are included for comparison. (auth)

**10614** THE DETERMINATION OF ATOMIC WEIGHTS BY MASS SPECTROMETRY. A. E. Cameron (Oak Ridge National Lab., Tenn.). Anal. Chem., 35: 23A-35A(Feb. 1963).

A critical analysis of mass spectrometry as used for atomic weight determinations is provided with special emphasis on the possible sources of error in the measurements. A comparison is also given between atomic weights determined by chemical procedures and those calculated from mass spectrometric data. (P.C.H.)

**10615** PHASE EQUILIBRIUM STUDIES FOR THE TERNARY SYSTEM URANYL NITRATE-NITRIC ACID-WATER. J. Gaunt, I. J. Bastien, and M. Adelman (Assumption Univ. of Windsor, Ont.). Can. J. Chem., 41: 527-30 (Feb. 1963).

Phase equilibrium studies were carried out on the system $UO_2(NO_3)_2-HNO_3-H_2O$ from −10° to 49.1°C over a wide concentration range of both $UO_2(NO_3)_2$ and $HNO_3$. No phase separation occurred above 49.1°C for the concentrations studied. The three hydrates of $UO_2(NO_3)_2$ were identified in the solid phase, and a new complex of $UO_2(NO_3)_2$, possibly

$UO_2(NO_3)_2 \cdot 3HNO_3$, was separated as the solid phase at higher nitric acid concentrations. (auth)

**10616** PHASE EQUILIBRIUM STUDIES FOR THE QUATERNARY SYSTEM URANYL NITRATE–ALUMINUM NITRATE–NITRIC ACID–WATER. Robert D. Thibodeau and M. Adelman (Assumption Univ. of Windsor, Ont.). Can. J. Chem., 41: 531-6(Feb. 1963).

The quaternary system $UO_2(NO_3)_2$–$Al(NO_3)_3$–$HNO_3$–$H_2O$ was studied in the temperature range 0–20°C, and the concentration range of 0 to 1.5 M $Al(NO_3)_3$ and 0 to 10 N $HNO_3$. From the data, phase diagrams were prepared. No phase separation was evident at 30°C and above, for the concentrations studied. (auth)

**10617** OPTICAL FARADAY ROTATION STUDIES OF PARAMAGNETIC RESONANCE IN NEODYMIUM ETHYLSULPHATE. K. E. Rieckhoff and D. J. Griffiths (Univ. of British Columbia, Vancouver). Can. J. Phys., 41: 33-45 (Jan. 1963).

The magneto-optical Faraday effect is used to measure the saturation of the spin levels in concentrated neodymium ethylsulphate in both steady-state and pulsed microwave resonance experiments at liquid helium temperatures. The steady-state experiments yield the paramagnetic resonance spectrum consisting of a main triplet and an extensive hyperfine structure. The line positions are explained in terms of the known spin hamiltonian of the diluted salt and spin-spin interaction between nearest neighbors. An asymmetry of the line shape is observed for sufficiently low temperatures in qualitative agreement with existing theories. Measurements of saturation s versus microwave power P at constant field and temperature are made and yield the relationship $s(P) = \alpha P^{1/2}/(1 + \alpha P^{1/2})$ for $s > 10\%$. The steady-state experiments also revealed the existence of a spatial gradient in the saturation across the sample. The pulsed experiments give the spin-lattice relaxation time $\tau$ as a function of magnetic field H at various temperatures. At 4.2°K, $\tau$ is found to be independent of H and of the order of 11 msec for fields from 800 to 2600 $\phi$, while at temperatures below 2°K, $\tau$ is found to be strongly field-dependent, indicating the importance of cross-relaxation effects at temperatures ≤2°K. (auth)

**10618** DISCOVERY AND DEVELOPMENT OF THE LANTHANON RARE EARTHS. Michael F. Berard (Iowa State Univ., Ames). Ceram. Age, [80]: 67-70(Aug. 1962). (IS-447)

Discussion is given on the history, first practical use, separation, and nuclear properties of the rare earths including Y, Sc, and La. The relative abundance of the lanthanon rare earths is tabulated and compared with a few commonly known elements. (P.C.H.)

**10619** CRYSTALLIZATION OF MIXED HYDROXIDES OF MAGNESIUM AND ALUMINUM IN DIALYZED MEDIUM. Max M. Mortland and Marie-Claire Gastuche (Laboratoire de Chimie Minerale, Institut Agronomique, Héverlé-Louvain, [France]). Compt. Rend., 255: 2131-3(Oct. 22, 1962). (In French)

Two solutions of 0.25M $MgCl_2 \cdot 6H_2O$ and $AlCl_3 \cdot 6H_2O$ were mixed in various ratios and taken to pH 10 with sodium hydroxide. The precipitates were purified by dialysis at 60°C for a month and then dried and examined. The pure Mg sample crystallizes in very pure brucite, whereas the pure Al is present in the form of a mixture of norstrandite, bayerite, and gibbsite. The products exist in two forms with slightly different parameters. They are found in the pure state only in a very narrow range of molar ratios. Chloride ion adsorption is observed for only two samples. The x-ray-diffraction diagrams and the morphology suggest the existence of a laminated structure. (J.S.R.)

**10620** GRAPHICAL METHODS FOR DETERMINING A NONLINEAR CONSTANT IN VAPOR PRESSURE EQUATIONS. Donald G. Miller (Univ. of California, Livermore). Ind. Eng. Chem., Fundamentals, 2: 68-73(Feb. 1963).

Graphical methods are given for the accurate determination of the nonlinear constant in vapor pressure equations and are applied to the Antoine and Miller-Erpenbeck equations. The schemes, involving derivatives or integrals of deviation functions, are feasible for hand calculation with seven-place logarithms and a desk calculator. Examples of the calculations are given for benzene and hexadecafluoroheptane. The results are especially good with the Antoine equation. In this case, the deviation of C from the best value is about 0.25% for the integral method and about 0.5% for the more rapid derivative method (an extension of Lu's scheme). An analysis of least square fits as a function of C shows that the best all-round fit is the least square fit to P rather than to log P. (auth)

**10621** PRECIPITATION OF ELEMENTS FROM FUSED SALTS. COMMUNICATION I. PRECIPITATION OF CERTAIN ELEMENTS FROM FUSED AMMONIUM NITRATE. V. K. Val'tsev, S. M. Artamonova, N. F. Didora, L. Kh. Kravchenko. Izv. Sibirsk Otd. Akad. Nauk SSSR, No. 4, 38-42(1961).

The use of fused $NH_4NO_3$ as a medium for conducting various reactions was studied; rare-earth elements (REE), alkaline earth elements, and also Th and U, were precipitated from $NH_4NO_3$. Solutions containing La, Nd, Dy, Er, Mg, Ca, Sr, Ba, Th, and U were obtained by dissolving the oxides of metals in fused $NH_4NO_3$. The process was carried out in a vertical tube resistance furnace made of heat-resistant glass, at a constant temperature of 180°C. It was proved that elements behaved differently when precipitated by different precipitants; $(NH_4)_2SO_4$ precipitates La, Nb, Er, and Ca; in this case there are exchange reactions, with precipitates formed, between the dissolved substances and the solvents; the compositions of the precipitates for REE differ in different subgroups. The Ca precipitates are binary sulfates. Na and K sulfates precipitate REE and certain alkaline earth metals. Th and U do not form insoluble precipitates with $(NH_4)_2SO_4$ in fused $NH_4NO_3$. $NH_4$ oxalate precipitates La, Nd, Dy, Ca, Mg, Sr, Ba, and Th, but not U. The analysis of the Nd and Dy precipitates showed that the binary oxalates $Nd_2(C_2O_4)_3 \cdot 0.6(NH_4)_2C_2O_4$ and $Dy_2(C_2O_4)_3 \cdot 0.6(NH_4)_2C_2O_4$ were formed. The oxalates of the alkaline metals act similarly to the $NH_4$ oxalate. (Referativnyy zhurnal. Khimiya, No. 7, 1962)

**10622** THE REACTION OF LITHIUM WITH WATER VAPOR. W. R. Irvine and J. A. Lund (Univ. of British Columbia, Vancouver). J. Electrochem. Soc., 110: 141-4 (Feb. 1963).

A thermal balance and x-ray diffraction study was made on the reaction of Li with water vapor. Water was carried at partial pressures of up to 12.6 mm Hg in oxygen and argon gases, and runs were conducted between 20 and 45°C. The reaction was found to proceed in three distinct successive stages: the formation at constant rate of a lithium hydroxide (LiOH) film believed to be coherent with the underlying Li metal lattice; the localized nucleation and growth by spreading of lithium hydroxide monohydrate ($LiOH \cdot H_2O$) at the outer surfaces of the hydroxide; and the simultaneous formation and hydration of the hydroxide at constant rate, culminating in complete conversion of the metal to the hydroxide monohydrate. (auth)

**10623** THE REDUCTION OF OXYGEN ON PASSIVE ZIRCONIUM. Robert E. Meyer (Oak Ridge National Lab., Tenn.). J. Electrochem. Soc., 110: 167-72(Feb. 1963).

The reduction of oxygen on film-covered zirconium was investigated by the measurement of the rate as a function of potential and concentration. The amount of hydrogen peroxide produced was measured and compared to the theoretical amount. The results showed two distinct polarization regions, a very low-current region with a Tafel slope of about 1.4 (2.3 RT/F) and an oxygen order of unity, and a higher current region with a much larger Tafel slope and a fractional oxygen order. Equations accounting for the general features of the data are derived based on a model that considers the separate potential drops across the film and the solution double layer. (auth)

**10624** ON THE RELATIVE TRANSITION PROBABILITIES OF BeO ($B^1\Sigma^+ - X^1\Sigma^+$) SYSTEM. N. R. Tawde and N. Sreedhara Murthy (Karnatak Univ., Dharwar, India). J. Opt. Soc. Am., 53: 298(Feb. 1963).

It was shown that some of the values of transition probabilities from previous research were in significant error. The discrepancies found were of physical significance, and their origin was discussed and noted for future guidance in such problems. (C.E.S.)

**10625** ISOTOPE SHIFT IN λ5556 Å OF YTTERBIUM. [PART] I. John S. Ross (Rollins Coll., Winter Park, Fla.). J. Opt. Soc. Am., 53: 299-300(Feb. 1963).

Enriched isotopic samples were excited in a liquid-nitrogen-cooled hollow-cathode discharge tube, with neon as the carrier gas. Spectrograms were obtained with a Fabry-Perot interferometer mounted externally to a Hilger E-495 spectrograph. The center-of-gravity locations for the odd isotopes were included. All values were listed relative to the 174 isotope. The even isotopes showed an increasing shift as neutron pairs were subtracted. The two lightest isotopic pairs showed an appreciably larger shift than the two heavier isotopic pairs. (C.E.S.)

**10626** FLUORESCENT LIFETIME OF TERBIUM IN THE PRESENCE OF OTHER RARE-EARTH IONS. G. E. Peterson and P. M. Bridenbaugh (Bell Telephone Labs., Inc., Murray Hill, N. J.). J. Opt. Soc. Am., 53: 301-2 (Feb. 1963).

Fluorescent lifetime measurements on the $^5D_4$ level of $Tb^{3+}$ were made by a stroboscopic technique in which the sample was pulsed 40 times per second through a Corning No. 7-60 filter by a Kemlite stroboscope tube. Detection was by means of a 1P21 photomultiplier pulsed to 1.5 kv for 2.5 μsec. Data were taken at room temperature with an estimated error of about 2%. It was concluded that a resonance phenomenon was active in the rare-earth system and that it was a satisfactory explanation for the strong quenching ability of Er, Ho, and Nd. (C.E.S.)

**10627** THE THERMODYNAMIC AND PHYSICAL PROPERTIES OF BERYLLIUM COMPOUNDS. I. ENTHALPY AND ENTROPY OF VAPORIZATION OF BERYLLIUM FLUORIDE. Michael A. Greenbaum, James N. Foster, M. Louis Arin, and Milton Farber (Rocket Power, Inc., Pasadena, Calif.). J. Phys. Chem., 67: 36-40(Jan. 22, 1963).

Using torsion effusion, gravimetric effusion, and transpiration techniques, the enthalpy and entropy of vaporization of $BeF_2$ were determined over the temperature range 550 to 950°. The enthalpy of vaporization in this temperature range was found to be 53.25 ± 0.25 kcal, while the corresponding entropy was found to be 38.7 ± 0.6 cal/deg/mole. A determination of the melting point of crystalline $BeF_2$ by means of vapor pressure measurements yielded a value of 542 ± 3°. Torsion effusion measurements of the effusing vapor show the gaseous species over liquid beryllium fluoride to consist of $BeF_2$. (auth)

**10628** THE OXIDATION OF HYDROGEN AND DEUTERIUM ON A ROTATING DISK ELECTRODE. Gerald P. Lewis and Paul Ruetschi (Electric Storage Battery Co., Yardley, Penn.). J. Phys. Chem., 67: 65-8(Jan. 22, 1963).

The oxidation of hydrogen and deuterium in alkaline solutions was studied by use of a rotating disk platinized platinum electrode. The variables investigated were KOH concentration, speed of rotation, electrode potential, and temperature. The rates for diffusion and ionization were determined. The currents decreased significantly as the KOH concentration was increased from 0.1 to 5.0 N. The product $k = DS^{5/3}$, where D is the diffusion coefficient and S the solubility, was determined for hydrogen and deuterium. The ratio of the k values of $H_2$ and $D_2$ was 3.5 in 0.1 N KOH at 30° and 3.3 at 50°. The ratios decreased successively as the KOH concentration increased and in 5.0 N KOH were 1.5 and 1.4 at 30 and 50°, respectively. The ratio of the maximum hydrogen ionization current to the maximum deuterium ionization current in the absence of diffusion effects was 1.8 in 0.1 N KOH at 30° and decreased to 1.5 in 5.0 N KOH at 30°. An increase in temperature from 30 to 50° increased the ionization current in both cases but the hydrogen current increased at a faster rate than the deuterium current. The difference in the rate of oxidation between hydrogen and deuterium suggests that a separation of the isotopes during the ionization process is possible. (auth)

**10629** THERMODYNAMICS OF LIQUID SOLUTIONS OF BISMUTH AND SULFUR. Daniel Cubicciotti (Stanford Research Inst., Menlo Park, Calif.). J. Phys. Chem., 67: 118-23(Jan. 22, 1963).

The pressure of $S_2$ in equilibrium with Bi–S melts was determined at 705, 740, and 800° over the concentration range from pure bismuth to the composition at which a second phase formed — solid $Bi_2S_3$ at 705 and 740°, and liquid S at 800°. A transpiration method was used in the lower pressure range and a dew-point method for the higher pressures. The thermodynamic quantities for solution of S and Bi in the melt were derived; these are discussed with regard to the possible nature of their binding in the melt. Evidence was found for the gaseous molecule BiS and its heat of dissociation was obtained. (auth)

**10630** IONIZATION AND DISSOCIATION PROCESSES IN PHOSPHORUS TRICHLORIDE AND DIPHOSPHORUS TETRACHLORIDE. Antonio A. Sandoval, H. C. Moser, and Robert W. Kiser (Kansas State Univ., Manhattan). J. Phys. Chem., 67: 124-6(Jan. 22, 1963).

Appearance potentials and relative abundances are reported for the principal positive ions in the mass spectra of phosphorus trichloride and diphosphorus tetrachloride. Probable ionization and dissociation processes are deduced from the energetics, and the heats of formation of the various ions are given. The following molecular ionization potentials are given: phosphorus trichloride, 10.75 ± 0.2 and diphosphorus tetrachloride, 9.36 ± 0.2 ev. Ionization potentials of PCl, $PCl_2$, and $P_2$ were calculated to be 9.6, 9.0, and 11.1 ev, respectively. $D\text{-}(Cl_2P\text{–}PCl_2) = 58$ kcal/mole. (auth)

**10631** THE KINETICS OF THE OXIDATION OF HYDROGEN PEROXIDE BY CERIUM(IV). G. Czapski, B. H. J. Bielski, and N. Sutin (Brookhaven National Lab., Upton, N. Y.). J. Phys. Chem., 67: 201-3(Jan. 22, 1963). (BNL-6162)

Studies were made on the kinetics of the hydrogen peroxide reaction with cerium(IV) in 0.8 N $H_2SO_4$ using a flow technique. The results confirm the two-stage mechanism previously proposed by others and in addition establish that $k_1 = 1.0 \pm 0.1 \times 10^6$ $F^{-1}$ $sec^{-1}$ at 25°C. (P.C.H.)

**10632** ON LARGE DIFFERENCES IN THE EQUILIBRIUM SOLUBILITIES OF HYDROGEN AND DEUTERIUM IN PLATINUM–PALLADIUM ALLOYS. Ted B. Flanagan (Univ. of Vermont, Burlington). J. Phys. Chem., 67: 203-4 (Jan. 22, 1963).

The absorption of deuterium and hydrogen by Pd–Pt alloys was investigated using the technique of direct absorption of the gases from acidic heavy and light water solutions. A significant difference was found in the equilibrium solubilities of hydrogen and deuterium at certain alloy compositions, 8.80 and 12.03% Pt. The large differences in isotopic solubilities suggest that the alloys may be utilized to effect an isotopic separation at 25°C. Results of tests on the feasibility of such a separation are given. (P.C.H.)

**10633** STUDY OF THE URANATES OF COBALT AND MANGANESE. E. F. Bertaut, A. Delapalme, F. Forrat, and R. Pauthenet (Centre d'Études Nucléaires, Grenoble, France and Laboratoire d'Electrostatique et de Physique du Métal, Grenoble, France). J. Phys. Radium, 23: 477-85 (Aug.-Sept. 1962). (In French)

The compounds $CoUO_4$ and $MnUO_4$ are isomorphous with $MgUO_4$. They are antiferromagnetic below $T_N = 12°K$. Their paramagnetic Curie temperatures are –23 and –8°K respectively. If the chemical unit cell a, b, c of $CoUO_4$ is described in the space group Imma, the magnetic unit cell has the periods 2a, b, 2c. The Néel sublattices are (121) planes with alternating + and – spins. The Néel temperatures are weak because the significant interactions are of the superexchange type at right angles and of the type super-superexchange. (auth)

**10634** KINETICS OF ISOTOPIC EXCHANGE BETWEEN GAS-PHASE OXYGEN AND OXYGEN TAKEN UP BY COMPLEX ORGANIC COMPOUNDS INVOLVING COBALT. G. M. Panchenkov and A. M. Tolmachev (Moscow State Univ.). Kinetika i Kataliz, 3: 861-4(Nov.-Dec. 1962). (In Russian)

Studies were made of isotopic exchange between gaseous oxygen and oxygen absorbed by complex organic cobalt compounds: bis-(N,N'-disalicylylethylenediamine)-μ-aquadicobalt and bis-(N,N'-di-(3-nitrosalicylyl)-ethytendiamine)-μ-aquadicobalt. The rate of the isotopic exchange reaction depends on the temperature. The scheme of the process was analyzed. (tr-auth)

**10635** INVESTIGATING THE PROCESS OF IODIDE REFINING OF NIOBIUM. V. S. Emel'yanov, G. A. Leont'ev, and A. I. Evstyukhin. Met. i Metalloved. Chistykh Metal., Sb. Nauchn. Rabot, No. 3, 127-36(1961).

Thermal dissociation of iodides was conducted by the Van Arkel scheme. Sublimated iodine was introduced into the apparatus without breaking the vacuum. The process was conducted in a small-size glass apparatus with a branch serving to establish the vapor pressure. Industrial cubic-shaped Nb, transformed into chips, was used as initial raw material. Of three parameters (filament, branch, and retort temperature) only one was varied. The filament temperature was 900°C in all the experiments; the retort temperature varied from 350 to 700°C. The rate of Nb deposition, at a temperature variation up to 600°C, increased monotonously with higher temperature of the branch piece (under these conditions $NbI_3$ is stable). At retort temperature >620°C a maximum appears on the deposition rate-branch temperature curves within the 225 to 250°C range ($NbI_5$ is stable). It is shown that the rate of Nb deposition at 650 to 700°C retort temperature is 19 times higher than the deposition rate at 350°C under optimum conditions, and is equal to $22.8 \times 10^{-3}$ mm/min. The O and H contents in metal iodide depend on the deposition process conditions and increase with a higher temperature of the branch. Experiments on an enlarged scale were also performed. (Referativnyy zhurnal. Metallurgiya, No. 6, 1962)

**10636** ENERGY LEVELS OF RARE EARTH IONS IN CUBIC CRYSTAL FIELDS. J. A. White (Harvard Univ., Cambridge, Mass.). Phys. Chem. Solids, 23: 1787-93(Dec. 1962).

Cubic crystal-field Stark splittings are calculated for the lowest term of the rare earth ions $Ce^{3+}$ through $Sm^{3+}$ and $Tb^{3+}$ through $Yb^{3+}$ for combined fourth and sixth order potentials. Energy level diagrams corresponding to eightfold coordination are given for seven choices of the ratio of sixth to fourth order terms, ranging from pure fourth order field to about five times the ratio to be expected on a point charge model. The splittings in different ions are compared on the assumption that the crystal field intensities and the expectation values for the fourth and sixth powers of the rare earth f-electron radius vary smoothly through the rare earth series. Experimental information on garnets suggests that the ratio of sixth to fourth order terms is about twice that to be expected on a point charge model for these crystals. For this ratio there is a marked tendency in ions to the right of gadolinium for the crystal field levels to cluster into two groups separated by a gap large compared with the spacings within each group. The total Stark splitting is found to be of comparable magnitude for all the rare earth ions, with somewhat larger values at the ends of the series than in the middle. (auth)

**10637** THE EFFECT OF PHOTOCHEMICAL PROCESSES ON THE LUMINESCENT PROPERTIES OF CdS SINGLE CRYSTALS. C. Albers (Universität Berlin). Phys. Status Solidi, 2: 1268-78(1962). (In German)

It is shown that characteristic changes occur in the luminescent spectrum of CdS crystals when illuminated with uv light above 0°C. The original state can be restored by heat treatment. It is emphasized that these changes may seriously affect measurements of the temperature dependence of luminescence, and a procedure is proposed which enables one to deduce the magnitude of the error. The luminescent intensity is found to decrease exponentially, at constant temperature and excitation intensity. The observed behavior is thought to be due to photochemical processes. (auth)

**10638** RELEASE OF INERT GAS FROM LABELED IONIC CRYSTALS DURING THERMAL TREATMENT. Č. Jech (Inst. of Physical Chemistry, Czechoslovak Academy of Sciences, Prague). Phys. Status Solidi, 2: 1299-1303(1962). (In English)

Release of radon-222 and xenon-133 labels, introduced into samples of a series of alkali metal chlorides by ionic bombardment, is measured during two types of thermal treatment. For a given chloride both gases are released in about the same temperature range, the position of which is dependent on the mass of cation in the chloride. The temperature and time dependence of the release is very similar to the characteristics of thermal recovery of changes induced in chlorides by ionizing radiation. This suggests that release occurs as a result of, or in connection with, the annealing of the radiation damage produced in the surface layers by the ion bombardment. (auth)

**10639** THE MÖSSBAUER EFFECT AND FERROELECTRIC PROPERTIES OF IONIC CRYSTALS. Č. Muzikář

(Charles Univ., Prague), V. Janovec, and V. Dvořák. Phys. Status Solidi, 3: K9-K12(1963). (In English)

Equations are given for the relation of the static permittivity of ionic crystals to homogeneous transversal optical modes of the lattice vibrations. The influence of the existence of an anomalous branch in the optical modes on the Mössbauer effect in ferroelectric materials was studied. It was found that the anomalous branch causes weakening of the intensity of the Mössbauer line when the temperature is lowered to the Curie temperature. (M.C.G.)

**10640** CONCERNING THE COLORING OF SYNTHETIC $CaF_2$ CRYSTALS OF HIGH PURITY. P. Goerlich, H. Karras, and R. Lehmann. Phys. Status Solidi, 3: 98-107(1963). (In German)

Calcium fluoride crystals were prepared from synthetic materials of very high purity. It was found that the passage of an electric current, the presence of metallic vapor, or deuteron bombardment, results in a coloration of the crystals. The spectra of the coloration were measured and its general features discussed. (auth)

**10641** EQUILIBRIUM DIAGRAM AND MELT MASS OF $UO_2$–$SiO_2$ SYSTEMS. S. N. Lungu (Inst. of Nuclear Physics, Bucharest). Rev. Phys., Acad. Rep. Populaire Roumaine, 7: 419-25(1962). (In Russian)

A phase diagram was developed for the $SiO_2$–$UO_2$ liquidus up to 2300°C, and crystallization of compounds with up to 7 g/cm$^3$ of $UO_2$ were studied. (R.V.J.)

**10642** DIFFUSION OF RADIOISOTOPES INTO GLASS. Jarmila Rálková. Silikaty, No. 3, 258-72(1962).

Diffusion coefficients of Cs and Sr in glass were measured using a thin-layer method. The glass composition (wt %) was: $SiO_2$, 72.0; $K_2O$, 11.75; CaO, 6.35; $Na_2O$, 6.35; ZnO, 2.9; $Sb_2O_3$, 0.43; and $As_2O_3$, 0.22. Values (cm$^2$/sec) obtained for Cs and Sr in the temperature range 300 to 600°C and 350 to 575°C, respectively, are tabulated. The activation energy of diffusion changes with temperature, and this is in accordance with the hypothesis on the activation of the glass structure. The diffusion coefficients of Cs are lower than those of other alkalis with smaller ionic diameters. However, the activation energy of diffusion of Cs is lower than that of Na and this is considered proof of the assumption that Cs is the most weakly bound element in glass. Cesium migrates faster than Sr at lower temperatures, owing to the fact that in this range fusion is affected by the valency of the ions. In the region of softening of the glass the diffusion coefficients of mono- and bivalent ions become approximately equal. The low values of the diffusion coefficients indicate that the sealing of highly radioactive elements into glass would be safe provided the rate of elution were limited solely by diffusion. (P.C.H.)

**10643** ISOTOPES IN PHYSICAL CHEMISTRY. Lars G. Erwall and Torbjoern Westermark (Kungiliga Tekniska Högskola, Stockholm). Svensk Kem. Tidskr., 74: 597-608 (1962). (In Swedish)

Important uses of radioactive and stable isotopes in physical chemistry are reviewed, with special emphasis on the work and ideas of Ole Lamm. Examples are given from the following fields: the dependence of nuclear properties on the chemical state; chemical effects of radioactive decay; interaction of radiation with matter, including applications of the Mössbauer effect in structural chemistry; and tracer applications in studies of distribution, diffusion, kinetics, and analytical chemistry. (auth)

**10644** THE STANDARD FREE ENERGY OF FORMATION OF CERIUM AND PRASEODYMIUM MONOCARBIDES. Edna A. Dancy (Carnegie Inst. of Tech., Pittsburgh), Lyndon H. Everett, and Charles Law McCabe. Trans. AIME, 224: 1095-1104(Dec. 1962).

It was found that the carbide phase present at equilibrium in the system M–$H_2$–$CH_4$, at about 600°C, is MC for the rare-earth metals Ce and Pr. X-ray diffraction analysis showed that the monocarbides have fcc structures with lattice constants of 5.036 ± 0.009Å and 5.131 + 0.001Å for CeC and PrC, respectively. Gaseous equilibrium measurements were used to calculate the standard free energy of formation of the monocarbides from the elements. $\Delta G^0_{815-940°K} = -27{,}900 + 8.2T$ (±1300) for the formation of CeC, and $\Delta G^0_{871-940°K} = -30{,}400 + 10.8T$ (±1300) for the formation of PrC. (auth)

**10645** THERMODYNAMICS OF SUBOXIDE VAPORIZATION. Leo Brewer and Gerd M. Rosenblatt (Univ. of California, Berkeley). Trans. AIME, 224: 1268-71(Dec. 1962).

Thermodynamic calculations predict the species vaporizing from metal-oxide mixtures when reliable free energy functions, enthalpies of formation, and dissociation energies are available for the possible gaseous and condensed oxide components. Calculations of the oxygen to metal ratio in the vapor phase compared with the oxygen to metal ratio in a liquid metal saturated with oxide impurity are presented. The possibility of purifying metals contaminated with oxide by vacuum melting or by distillation is discussed. Kinetic considerations affecting rates are neglected. (auth)

**10646** THE TEMPERATURE DEPENDENCE OF THE NUCLEAR QUADRUPOLE COUPLING CONSTANTS OF $Na^{23}$ IN SODIUM NITRITE, $NaNO_2$. Alarich Weiss and D. Biedenkapp (Technische Hochschule, Darmstadt, Ger.). Z. Naturforsch., 17a: 794-8(Sept. 1962). (In German)

The nuclear quadrupole coupling constant of $Na^{23}$ in sodium nitrite, $NaNO_2$, was investigated between 18 and 215°C. Below the transition temperature (163 ± 2)°C the asymmetry parameter $\eta = (\varphi_{xx} - \varphi_{yy})/\varphi_{zz}$ decreases with increasing temperature and goes to zero at the transition point. Above 163°C $\eta$ is negative and $|\eta|$ increases with temperature. This temperature dependence of the nuclear quadrupole coupling cannot be explained adequately by the point charge model together with the assumption of the free rotation of the $NO_2$ group above the transition point. (auth)

**10647** THE TEMPERATURE DEPENDENCE OF THE MOBILITY VARIATION OF THALLIUM ISOTOPES IN MOLTEN TlCl. W. Fischer, K. Heinzinger, W. Herzog, and A. Klemm (Max-Planck-Institut für Chemie, Mainz). Z. Naturforsch., 17a: 799-805(Sept. 1962). (In German)

The mass effect in the temperature range 470°C $\leq \vartheta \leq$ 680°C was measured for the migration of Tl ions in molten TlCl. In linear approximation the result was $\mu_+ = -0.045\{1 - 0.001(\vartheta - 470)\}$. The temperature effect can be explained both with a temperature-increasing contribution of complexes to the transport and also with an increase of the relative frequency of coupled transitions with increasing temperature. (tr-auth)

**10648** THE PHENOMENOLOGY OF ISOTHERMAL DIFFUSION IN ELECTROLYTES. A. Klemm (Max-Planck-Institut für Chemie, Mainz). Z. Naturforsch., 17a: 805-7 (Sept. 1962). (In German)

Mobility coefficients or mobilities are suitable for the representation of particle transport properties of isothermal electrolytes when one of the components of the electrolyte can be considered as a natural reference system. If such a component is missing, the representation is preferable with friction coefficients. A later calculation of the

self-diffusion in pure salts was improved by compound kinetic units (with neglect of the "exchange" diffusion). (tr-auth)

**10649** THE MECHANISM OF THE SULPHUR SENSITIZATION OF PHOTOGRAPHIC EMULSIONS. H. Frieser and E. Ranz (Technische Hochschule, Munich). Z. Naturforsch., 17a: 821-2(Sept. 1962). (In German)

Investigations were undertaken to clarify the mechanism of the S sensitization of photographic emulsions. Sodium thiosulfate with exterior S atoms labeled with $S^{35}$ was used for the sensitization. An ammonium aged highly halated emulsion and a non-ammonium aged non-halated emulsion were used. After exposure the emulsions were treated in various ways. The results are shown graphically and indicate that at optimum sensitization only very little silver sulfide is formed. With too much over-aging or sensitization of the emulsion at low $p_{Ag}$ more silver sulfide is formed. No silver sulfide can be detected with too short an aging period. Almost no thiosulfate is removed by prolonged washing. Both unaltered thiosulfate and silver sulfide apparently work as bromate acceptors. The formation of direct black grains was explained by the adsorption of thiosulfate on metallic silver and its transformation to silver sulfide. (J.S.R.)

**10650** THE LUMINESCENT SPECTRA OF AQUEOUS THALLIUM SALT SOLUTIONS WITH AND WITHOUT ADDITIONS OF ALKALI HALOGENIDES. P. Brauer and D. Pelte (Universität, Freiburg i. B.). Z. Naturforsch., 17a: 875-83(Oct. 1962). (In German)

The emission spectra of aqueous TlCl solutions with and without additions of alkali chlorides up to saturation concentrations and the emission spectra of TlBr and $Tl_2SO_4$ solutions were investigated. A broad band was found that has a maximum that depends on the composition of the solution and the spectrum of the exciting light. It was shown that these various spectra can be understood as superpositions of three symmetrical single bands of which each is assigned to the dissolved $Tl^+$, TlCl, and $TlCl_2^-$. Their maxima lie at 3680, 3950, and 4400 Å, and their half-widths are 5300, 4950, and 4750 $cm^{-1}$. Analogous ratios appear to be present in TlBr-alkali bromide solutions, yet the assignment of given bands to given complexes cannot be given. (tr-auth)

**10651** DETERMINATION OF THE LIFETIME OF EXCITED STATES BY TIME MEASUREMENT ON OPTICAL MASERS. K. Guers (Siemens and Halske A. G., Munich). Z. Naturforsch., 17a: 883-5(Oct. 1962). (In German)

From measurements of the emission pattern of optical masers at the threshold, the lifetime of the $^4F_{\frac{3}{2}}$ excitation state of Nd in calcium tungstate was determined as 0.127 msec and that of the $^2E$ state of ruby as 3.0 msec, both at room temperature. The lamp output, which was necessary for continuous operation in the apparatus used, was given. (tr-auth)

**10652** PARAMAGNETIC SPIN-LATTICE RELAXATION OF HYDRATED CHLORIDES OF Nd, Gd, Dy, AND Er IN THE TEMPERATURE REGION FROM 1.1 TO 4.2°K. Guenter Weber (Technische Hochschule, Darmstadt, Ger.). Z. Physik, 171: 335-48(1963). (In German)

The paramagnetic relaxation of $RECl_3 \cdot 6H_2O$ where RE = Nd, Gd, Dy, and Er was investigated with the Hartshorn bridge in magnetic alternating fields of low frequency and, in addition, parallel external magnetic fields at temperatures between 1.1 and 4.2°K in single crystals and conglomerations. The spin-lattice relaxation times were determined by the frequency dependence of the complex susceptibility or by the behavior of the adiabatic susceptibility at single magnetic field changes. The temperature and field-strength dependence of the measured time constants corresponded at the higher temperature to the results expected from the theory for two-phonon processes with regard for the crystalline Stark effect. At the lower temperature the relaxation time deviated from the theoretical prediction. (tr-auth)

**10653** A STUDY OF M CENTER FORMATION IN ADDITIVELY COLORED KCl. Charles J. Delbecq (Argonne National Lab., Ill. and Technische Hochschule, Stuttgart). Z. Physik, 171: 560-81(1963). (TID-17106; UAC-6784). (In English)

Additively colored crystals of KCl were cooled rapidly from a high temperature and then exposed to light absorbed by the F band. The rate of growth of the M band was initially low and increased markedly during the first part of the irradiation giving rise to what is called a "delay period" in the M center formation. During this delay period it was observed that the quantum efficiency of F center fluorescence decreases by a factor of 3 or 4, and the ability to convert F centers to F′ centers is reduced by about a factor of 3. These effects are interpreted as arising because of an appreciable decrease in the average nearest neighbor F center separation during this period. Results are also presented concerning the kinetics of M center formation, oscillator strengths of the M center transitions, the degree of polarization of the M center fluorescence, and the transfer of energy from an excited F center to an M center. (auth)

**10654** POTENTIOMETRIC INVESTIGATIONS ON PLUTONIUM. K. Schwabe and D. Nebel (Zentralinstitut fur Kernphysik, [Dresden]). Z. Physik. Chem. (Leipzig), 220: 339-54(1962). (In German)

The complex formation between $Pu^{4+}$ or $Pu^{3+}$ and acetate ions was investigated. The complex constants were measured from the determination of the modification of the redox potential with the concentration of the acetate ions. Under the assumption that at equal initial concentrations of $Pu^{4+}$ and the same measurement methods, a minimum $Pu^{3+}$ concentration, equally large in each research series, is present, the potential in dependence on the acetate concentration was measured from the free $Pu^{4+}$ ions. The standard potential $Pu^{4+}/Pu^{3+}$ was estimated. (J.S.R.)

**10655** THE GIBBS STATISTICS OF ISOTOPE SYSTEMS. G. Vojta (Karl-Marx-Universität, Leipzig), Z. Physik. Chem. (Leipzig), 220: 420-8(1962). (In German)

With the formalism of the large canonical unity, a general proof was given that, for ideal as well as for real gases in thermodynamic equilibrium, all thermodynamic effects, including the chemical isotope effect, are pure quantum effects. In the generalization of a proof by J. E. Mayer it was shown that for gases of many chemically different components with many molecular types of varying isotopic composition the classical statistics yield no isotope effect, that is, no isotope separation effect. (tr-auth)

**10656** ION ASSOCIATION IN SOLUTIONS. XI. TESTING OF REISS THEORY. A. M. Sukhotin and E. M. Ryzhkov (Leningrad Inst. of Applied Chemistry). Zh. Fiz. Khim., 36: 2693-8(Dec. 1962). (In Russian)

An experimental test of Reiss' theory of ion association was made using LiI solutions in butanol–hexane mixtures. It is shown that the theory has no advantage over earlier theories with respect to description of the dependence of dissociation constants of the ionic pairs upon the dielectric constant and temperature. It was found that Reiss' theory

cannot explain the minima on the conductivity isotherms observed in media with low dielectric constant. (auth)

**10657** PHYSIOCHEMICAL CONSTANTS OF HEAVY-OXYGEN WATER. O. V. Uvarov, N. M. Sokolov, and N. M. Zhavoronkov (Karpov Inst. of Physics and Chemistry, USSR). Zh. Fiz. Khim., 36: 2699-2706(Dec. 1962). (In Russian)

The separation factor $\alpha$ of the system $H_2O^{16}-H_2O^{18}$ was determined in the range 20 to 210° by a differential method. At 100°, $\alpha = 1.0038$. The difference in vapor pressures of standard water and water enriched with $H_2O^{18}$ to 43.6 mole % was measured. From the values of $\alpha$, calculations were made of the difference in the heats of vaporization, of the vapor pressure of 100% $H_2O^{18}$ in the range 20 to 210°C and of its boiling point at 760 mm Hg. With the aid of an interferometer, the dependence of the difference in refractive indexes for $H_2O^{18}-H_2O^{16}$ upon the $H_2O^{18}$ concentration in water at 20° was determined. It was found that this dependence is of linear character. The temperature coefficient of the refractive index difference $H_2O^{18}-H_2O^{16}$ in the range 10 to 30° was determined. The density and its dependence upon the $H_2O^{18}$ concentration were determined by a quartz pycnometer at 25, 30, and 40°. The dependence is in the form of a straight line. On the basis of the relationship obtained, it was calculated that 100% $H_2O^{18}$ at 25° has a density 1.10723 times that of river water. The temperature dependence of the density of heavy oxygen water in the range 25 to 40° was also determined. The accuracy of the density determination was ±0.00001 g/cm$^3$. The $H_2O^{18}$-enriched water was purged of deuterium by the iron–steam method. Isotopic analysis of the purified water was carried out by mass spectrometer and the drop method. (auth)

**10658** ON THE INTERRELATIONSHIP BETWEEN SOME THERMODYNAMIC ELECTRONIC AND ELECTROCHEMICAL PROPERTIES OF METALS. I. RELATION BETWEEN THE WORK FUNCTION: ZERO CHARGE POTENTIALS AND FREE ENERGIES OF THE METALLIC LATTICES. N. E. Khomutov (Mendeleev Inst. of Chemistry and Tech., Moscow). Zh. Fiz. Khim., 36: 2721-6(Dec. 1962). (In Russian)

The relation between work function and the free heat content, $\Delta Z$, and enthalpy, $\Delta H$, of metallic lattices was examined and is shown to be linear. For many metals the experimental data are well described by the expression $\varphi = 0.305\,\Delta Z_2$ where $\Delta Z_2$ is the change in free heat content on sublimation of the metal and subsequent ionization of the atoms to di-charged ions (referred to 1 gram equivalent). The equation $\epsilon = -4.72 + 0.305\Delta Z_2 V$ was proposed for calculating the zero charge potential $\epsilon$. (auth)

**10659** MIGRATION AND MOBILITY OF Li IONS IN AQUEOUS $LiNO_3$ SOLUTIONS. E. A. Bakulin (Ioffe Inst. of Physics and Tech., USSR). Zh. Fiz. Khim., 36: 2782-4(Dec. 1962). (In Russian)

Lithium ion migrations were measured in $LiNO_3$ solutions of 6.5 to 22.6 M at 20 to 40°C. Li migration increased with electrolyte concentration. Temperature concentration data are tabulated. (R.V.J.)

**10660** ELUTION OF U(VI) IONS FROM SULFOCATION COLUMNS. A. I. Zhukov, E. I. Kazantsev, Yu. M. Kharchevnikov, and V. I. Nikulishev. Zh. Prikl. Khim., 35: 1893-1900(Sept. 1962). (In Russian)

Studies of the influence of pH on the sorption, eluate acidity, temperature, amount of resin, and other factors in uranium(VI) elution from columns of KU-2, SDV-3, MSF-3, KU-1, and SBS-1 resins by stoichiometrically neutral ammonium nitrate solutions showed that U(VI) can be completely eluted only from KU-2 and SDV-3. The experimental data were in agreement with an assumption that incomplete separation is due to ion complexing with the resins. (R.V.J.)

**10661** THE RATE OF CO REDUCTION OF $Nb_2O_5$. P. V. Gel'd and V. D. Lyubimov. Zh. Prikl. Khim., 35: 1940-5(Sept. 1962). (In Russian)

Kinetics of carbon monoxide reduction of $Nb_2O_5$ to $Nb_2O_4$ at 800 to 1050°C and 20 to 300 mm mercury pressure showed that the rate of the total process is regulated by the transformation intensity developed in the adsorption layer. The activation energy of the indirect $Nb_2O_5$ reduction is ~25 kcal, and the reaction rate increases as $P_{CO}^{0.5}$ with carbon oxide pressure. (R.V.J.)

**10662** PRODUCTION OF BORON CARBIDES IN CARBON REDUCTION OF RARE EARTH MIXTURES WITH BORON. L. Ya. Markovskii, N. V. Vekshina, and G. F. Pron. Zh. Prikl. Khim., 35: 2090-1(Sept. 1962). (In Russian)

Carbon reduction of $CeO_2$ or $La_2O_3$ mixtures with B at 1900 to 2000°C produced borocarbides similar to Ca, Sr, and Ba borocarbides. The synthesized products contained considerable amounts of chemically unstable compounds that in hydrolytic disintegration transform into a boron-metal solution and carbon. (R.V.J.)

**10663** X-RAY DIFFRACTION ANALYSIS OF Sc, Y, Ce, Nd, AND Gd ORTHOVANADATES. V. A. Naymov (State Scientific-Research and Planning Inst. of Nitrogen Industry and Products of Organic Synthesis, Lisichansk, USSR). Zh. Strukt. Khim., 3: 608-11(Sept.-Oct. 1962). (In Russian).

Studies were made of Sc, Y, Ce, Nd, and Gd orthovanadate elementary cell parameters, and x-ray diffraction diagrams are given for $ScVO_4$, $YVO_4$, $CeVO_4$, $NdVO_4$, and $GdVO_4$. (R.V.J.)

**10664** SYSTEMATICS OF ATOMIC RADII. S. S. Batsanov (Novosibirsk Inst. of Inorganic Chemistry, Academy of Sciences, Siberia, USSR). Zh. Strukt. Khim., 3: 616-28 (Sept.-Oct. 1962). (In Russian)

Systematic arrangement of metallic covalents and ionic radii are reviewed and methods of their applications in structural chemistry are analyzed. (R.V.J.)

## Organic Chemistry

**10665** (BNL-6174) THE SECONDARY $\alpha$-DEUTERIUM ISOTOPE EFFECT IN THE THERMAL DECOMPOSITION OF $\alpha$-PHENYLETHYLAZO-2-PROPANE. Stanley Seltzer (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT(30-2)-Gen-16]. 24p.

$\alpha$-Phenylethyl-$\alpha$-d-azo-2-propane(II) and $\alpha$-phenylethylazo-2-propane-2-d(III) were prepared. The rates of decomposition of these compounds, in addition to the natural compound (I), were measured and compared. The isotope effects are $k_I/k_{II} = 1.15$ and $k_I/k_{III} = 1.04$. It is concluded that both C–N bonds break simultaneously and the $\alpha$-phenylethyl C–N bond is stretched considerably more than the 2-propyl C–N bond in going from the starting state to the transition state. An apparent contradiction of two rules predicting the structure of the transition state is discussed. (auth)

**10666** (RAI-303) DEVELOPMENT OF TRANSPARENT PLASTIC MOISTURE BARRIERS BY RADIATION-INDUCED GRAFT POLYMERIZATION. Period Covered: December 1, 1960 through August 31, 1962. (Radiation Applica-

tions Inc., Long Island City, N. Y.). Sept. 5, 1962. Contract NOw 61-0407-c. 30p.

Work was carried out on the synthesis of packaging materials having moisture barrier properties. The approach investigated has involved the modification of polyethylene via the techniques of halogenation and graft polymerization of halogenated monomers. The grafting of pure vinylidene chloride to polyethylene was inefficient due to the difficulty in separating the grafted product from the homopolymer. This problem was overcome by employing vinylidene chloride diluted with a small amount of acrylonitrile. Facile graft polymerization occurred in the latter case. It was found that the graft polymers so formed have markedly reduced WVTR (water vapor transmission rate) values compared to untreated polyethylene. Chlorination and fluorination of polyethylene did not improve the WVTR properties of polyethylene. Difficulties were encountered in obtaining sizable degrees of fluorination. Appreciable amounts of chlorotrifluoroethylene were grafted to polyethylene. This did not result in a lowering of the WVTR value due to the degradation of the graft during irradiation. (auth)

**10667** (TID-15433) SPECTRAL ABSORPTION STUDIES IN THE 8-QUINOLINOL FAMILY. O. Popovych and L. B. Rogers (Massachusetts Inst. of Tech., Cambridge and Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). [Apr. 12, 1962]. Contract [AT(30-1)-905]. 25p.

Absorption spectra were determined for aqueous solutions of 8-quinolinol (oxine), oxine-5-sulfonic acid, 2-methyl-oxine-5-sulfonic acid, 2-methyl-oxine, 5,7-dichloro-oxine, 5-nitroso-oxine, and 5-amino-oxine as well as for the zinc chelates of the first four ligands and the magnesium chelates of the first three. Spectral variations due to changes in pH, substitution on the ligand, and chelation were correlated with the direction of polarization in the oxine ring. A comparative spectral study on a series of oxinates and 2-methyl-oxinates showed the existence of steric effects, manifested by blue shifts, in the latter series. Compared to those of zinc chelates, absorption spectra of magnesium chelates showed relative enhancement of the adjacent shorter-wavelength band over the long-wavelength band. Enhancement of the first was attributed to a preferential metal–oxygen bond (ionic), while the large general red shifts and enhancements of the second, which are observed for most chelates, was attributed to a strong metal–nitrogen (covalent) bond. (auth)

**10668** (NP-tr-941) ACTION OF BROMOFORM AND CHLOROFORM ON SOME PYRROLES. O. Bocchi. Translated by L. Pirt (U.K.A.E.A. Atomic Energy Research Establishment, Harwell, Berks, Eng.) from Gazz. Chim. Ital., 30: 89-96(1900). 11p.

The reactions of chloroform and bromoform with $\alpha,\alpha'$-dimethylpyrrole, $\alpha,\beta'$-dimethylpyrrole, and $\alpha$-methyl-$\alpha'$-phenylpyrrole were studied. The first pyrrole yielded $\beta$-chloro-$\alpha,\alpha'$-dimethylpyridine and $\beta$-bromo-$\alpha,\alpha'$-dimethylpyridine on reaction with chloroform and bromoform, respectively. For the two other pyrroles, the yield of pyridine bases is much lower and complicated by the formation of isomeric pyridines. (D.L.C.)

**10669** (NP-tr-942) THE CONVERSION OF PYRROLE TO PYRIDINE. M. Dennstedt and J. Zimmermann. Translated by V. Newton (U.K.A.E.A. Atomic Energy Research Establishment, Harwell, Berks, Eng.) from Chem. Ber., 17: 336-19(1885). 8p.

An experiment on the direct conversion of pyrrole to pyridine was carried out by heating methylene iodide with potassium pyrrole and sodium alcoholate in a closed tube. The yield of pyridine was very small. (M.C.G.)

**10670** RELATIVE RATES OF BASE-CATALYZED RACEMIZATION AND DEUTERIUM EXCHANGE OF ARYL 2-OCTYL SULFONES. Harlan L. Goering, Donald L. Towns, and Bruce Dittmar (Univ. of Wisconsin, Madison). J. Org. Chem., 27: 736-9(Mar. 1962).

The rates of base-catalyzed (sodium methoxide) racemization ($k_{rac}$) and exchange of deuterium for hydrogen ($k_{exc}$) of phenyl and p-tolyl 2-octyl-2-d-sulfone in methanol at 100° were determined. The phenyl sulfone racemizes and exchanges more rapidly than the p-tolyl analog. With each sulfone, exchange exceeds racemization, $k_{exc}/k_{rac}$ is 17 for the phenyl sulfone and 14 for the p-tolyl sulfone. Thus exchange occurs for the most part with preservation of optical configuration. This shows that carbanions stabilized by sulfone groups are nonplanar, enantiomeric sulfones give enantiomeric carbanions. (P.C.H.)

## Radiation Chemistry and Radiochemistry

**10671** (AERE-M-1153) FLUORESCENT DECAY OF ANTHRACENE IN THE REGION 0.1–10 μsec. M. McN. Wasson (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). Dec. 1962. 5p.

Measurements were made of the long-term decay of the fluorescence induced in anthracene by alpha particles, protons, and electrons. Results are presented in tables and graphs. It was found that from 0.1 to 10 μsec the decays all follow the same power low type of decay: $I = I_0(1 + t/t_0)^{-1.3}$ where $I_0$ is the initial intensity and $t_0$ is a constant. (M.C.G.)

**10672** (BNL-6097) IRRADIATION INDUCED EFFECTS IN MAGNESIUM OXIDE CATALYSTS. J. Hoigne and D. Ballantine (Brookhaven National Lab., Upton, N. Y.). [1961]. Contract [AT-30-2-GEN-16]. 21p.

An attempt was made to find a model system in which to study irradiation effects on heterogeneous catalysts. Preirradiation with gamma rays from $Co^{60}$ enhanced the rate of hydrogen conversion over MgO catalysts, especially when the oxide was pretreated with oxygen at elevated temperature. No correlation could be found between the catalytic activity and the formation of paramagnetic centers observed in the electron spin resonance spectra at room temperature. Irradiation produced no detectable change in the adsorption properties of magnesium oxide for hydrogen and carbon monoxide. While the results do not permit the establishment of a positive reaction mechanism they do permit the elimination of several of the possible alternatives. (auth)

**10673** (BNL-6535) INFLUENCE OF LOW CONCENTRATIONS OF CRYSTAL DEFECTS ON THERMAL ANNEALING OF RECOIL $Br^{82}$ IN HEXABROMOETHANE. Kenneth E. Collins and Garman Harbottle (Brookhaven National Lab., Upton, N. Y.). [1963]. Contract [AT(30-2)-Gen-16]. 19p.

The effects of defects produced by gamma radiation exposures of 2 to 1400 r on the subsequent thermal annealing of $Br^{82}$ in crystalline $C_2Br_6$ was investigated at 0 to 120°. Incorporation of recoil $Br^{82}$ into $C_2Br_6$ during annealing occurs by several processes. One process is dependent on radiation dose while the others are independent of dose in the range studied. The dose-dependent annealing process apparently does not occur in the absence of radiation-produced defects or intracrystalline $Br_2$ and involves a long range diffusion mechanism. The dose-independent

annealing is discussed in terms of "intra-site" reactions of species produced in isolated (n,γ) events. (auth)

**10674** (BRL-1177) THE EFFECTS OF ALPHA PARTICLES ON LOW DENSITY POLYETHYLENE. Joe A. Swisher (Ballistic Research Labs., Aberdeen Proving Ground, Md.). Nov. 1962. 31p.

Polyethylene samples were exposed to two different size $Po^{210}$ alpha sources for increasing durations of time. The resulting chemical changes were studied as a function of absorbed energy by means of infrared spectroscopy. The radioinduced chemical changes observed in the infrared spectra of the polymer resulted in an increase in absorption at the characteristic frequencies of the new chemical bonds. Two methods were used to correlate the analytical data with the alpha particle exposure. One method involves the characteristic infrared band frequencies and the other, the correlation of the integrated areas of the infrared spectra. The results indicate the potentiality of polyethylene as a detector for alpha particles and a calibration tool for polonium alpha sources in the range of one millicurie to one curie. (auth)

**10675** (IS-425) RADICAL AND MOLECULAR REACTION MECHANISMS FOR (γ,n) ACTIVATED $C^{11}$ REACTIONS IN LIQUID CYCLOHEXANE. Edward P. Rack and Adolf F. Voigt (Ames Lab., Ames, Iowa). [Mar. 1, 1962]. Contract [W-7405-eng-82]. 27p.

A study was made of the yields of gaseous products labelled with $C^{11}$ from the $C^{12}(\gamma,n)$ reaction in liquid cyclohexane. The effects of variations in the radiation dose and in the concentration of dissolved $I_2$ during irradiation on the yields of these products were studied to elucidate the reaction mechanisms. A reaction model was developed as a method of assessing the relative importance of radical and molecular processes. The data suggest that the formation of $C^{11}$ labeled $CH_4$, $C_2H_4 + C_2H_6$, and $C_3H_6$ involves a hot radical process while the formation of $C_2H_2$ is by a molecular reaction with cyclohexane. (auth)

**10676** (NP-12231) LA PRODUCCIÓN DE RADIOISÓTOPOS EN UN SINCROCICLOTRÓN. INFORME NO. 68. (Production of radioisotopes with a Synchrocyclotron. Report No. 68). M. C. Palcos, R. Radicella, and J. Rodríguez (Argentina. Comision Nacional de Energia Atomica, Buenos Aires). 1962. 12p.

Possibilities for the use of a synchrotron for the production of radioisotopes are briefly considered in an analysis of its advantages and disadvantages. Because of the importance of the maximum surface of the particle bundle, the geometry of the bundle is briefly described. The techniques developed and the criteria used for the irradiation of various materials, with special reference to the preparation of targets, are discussed. Methods perfected for the production and chemical separation of carrier-free $Be^{7}$, $Na^{22}$, $Ca^{45}$, $Ca^{47}$, $Mn^{54}$, $Fe^{59}$, $Sr^{85}$, $Y^{88}$, $In^{111}$, and $Bi^{206}$ are given. Some of these isotopes are produced routinely. (tr-auth)

**10677** (NP-12235) CALIBRACIONE DE RADIOISOTOPOS EN LA CNEA. INFORME NO. 73. (Calibration of Radioisotopes by CNEA. Report no. 73). R. H. Rodríguez-Pasqués (Argentina. Comisión Nacional de Energía Atómica, Buenos Aires). 1962. 15p.

The procedures and instrumentations used by CNEA for the absolute measurement of radioactivity with respect to the production and fractionation of radioisotopes and labeled molecules are given. Examples of the results obtained with 4π proportional counters are included. (tr-auth)

**10678** (PAN-306/XVII) INFLUENCE DU RAYONNEMENT γ SUR LES POLYESTERS. ALIPHATIQUES. [PART] I. (Gamma Radiation Effects on Aliphatic Polyethers. [Part] I). Andrzej Orszagh, Helena Czarnodola, Zofia Gorska, and Janina Zurakowska-Orszagh (Polish Academy of Sciences. Inst. of Nuclear Research, Warsaw). Mar. 1962. 9p.

Characteristic viscosity variability and the number of carbooxyl and hydrooxyl groups in irradiated polyethers of $HO[-(CH_2)_n OOC(CH_2)_m^-]COOH$, where n = 2 and 3 and m = 4, 7, and 8, were investigated. (tr-auth)

**10679** (TID-15898) PARAMAGNETIC RESONANCE OF PHOTOLYZED SOLID HYDROGEN PEROXIDE. J. A. McMillan and B. Smaller (Argonne National Lab., Ill.). Apr. 1962. Contract [W-31-109-eng-38]. 19p. (UAC-6356)

Samples of hydrogen peroxide were photolyzed by ultraviolet light at 77°K and observed for paramagnetic resonance. From energetic considerations, the expected primary products are hydroxyl radicals, but their subsequent and almost instantaneous reaction with the parent molecule $H_2O_2$ yields the radical $HO_2$. The so-formed radical undergoes recombination at 77°K following a pseudo-monomolecular rate law producing oxygen molecules that remain substitutionally trapped in the lattice. These centers trap the remaining $HO_2$ radicals changing slightly their magnetic parameters. Further recombination at a slower rate discloses a much weaker absorption that is tentatively attributed to the radical $H_2O_2^+$. The mechanism of diffusion and recombination of the $HO_2$ radical is discussed and a kinetic scheme is proposed to account for the experimental results. (auth)

**10680** (TID-17584) EFFECTS OF MERCAPTANS AND DISULFIDES ON PHOTOCHEMICAL AND HIGH ENERGY RADIATION INDUCED REACTIONS. Progress Report, November 1, 1961–November 1, 1962. Saul G. Cohen (Brandeis Univ., Waltham, Mass.). Contract AT(30-1)-2499. 30p.

Light-induced reductions of benzophenone by 2-propanol to benzpinacol and, in the presence of sodium 2-propoxide, to benzhydrol were studied, and the effects of 2-mercaptomesitylene, mesityl disulfide, and naphthalene were examined. Rates of formation of benzpinacol and of benzhydrol are nearly equal in the absence of retarders, rates of reduction of benzophenone differing by a factor of about 2. The mercaptan and disulfide retard formation of benzhydrol about $^1/_{10}$ as effectively as they retard formation of benzpinacol. It is concluded that radical $(C_6H_5)_2COH$, is formed during inhibition of formation of benzpinacol by S compounds and that benzpinacol is not an intermediate in the formation of benzhydrol, the latter resulting from disproportionations involving radical ion $(C_6H_5)_2C-O^-$. Naphthalene is equally effective in retarding formation of benzpinacol and benzhydrol, but is only about $^1/_{10}$ as effective as the S compounds in retarding formation of benzpinacol. Naphthalene must quench short-lived excited benzophenone, while the S compounds react with longer-lived radicals. The reactions show linear dependence of $1/\Phi$ on concentration of quencher or retarder. (auth)

**10681** (TID-17743) THE SPECTRUM, THE EXCITATION AND IONIZATION CROSS-SECTIONS FOR PHOTO PROCESSES AND FOR COLLISIONS, OF FIVE TIMES IONIZED OXYGEN. Quarterly Report No. 6, September 1, 1962–November 30, 1962. Carlos M. Varsavsky (P.E.C. Corp., Boulder, Colo.). Contract AT(11-1)-1017. 21p.

A method for computing photoionization cross sections is being developed and tested. The screening approxima-

tion used was found to be particularly suited for highly ionized systems. Theoretical foundations of the method are presented. The application of the screening approximation to the calculation of bound-free transitions is considered. Results were obtained for Li, Mg, O, and Na. (M.C.G.)

**10682** CHANGES IN STANDARD SOLUTIONS OF $I^{131}$ UPON AGING. M. Hoebel (Universität, Heidelberg). Arch. Exptl. Pathol. Pharmakol., 241: 527(1961).

An aqueous carrier-free $I^{131}$ solution stored for 1 week was submitted to chromatography using n-butanol/3N $NH_4OH$ as solvent. In addition to the $I^{131}$ spot on the chromatogram, several other radioactive components were detectable. These were designated zone 1 ($R_f$ 0.0), zone 2 ($R_f$ 0.08-0.12), and zone 4 ($R_f$ 0.34-0.41). Appearance of the 3 zones was accelerated when the solution was stored in the presence of $O_2$; daylight had a similar effect. Replacement of $O_2$ by $N_2$ considerably retarded their appearance. Ultraviolet irradiation in the presence of $O_2$ increased the formation of zones 2 and 4, and especially that of the zone 1 component. By direct oxidation of $I^{131}$ (as the iodide) by NaOCl, zone 1 and 4 components were formed but not zone 2. If the oxidation products were reduced with $H_2S$ before chromatography, only the original iodide-$I^{131}$ was obtained. The zone 1 component appears to be $I^{131}O_3^-$. (H.H.D.)

**10683** POSSIBILITIES OF PREPARING LABELED DRUGS BY NEUTRON ACTIVATION. H. Schniewind, W. Braun, and M. Kraemer (Universität, Hamburg). Arch. Exptl. Pathol. Pharmakol., 241: 527-8(1961).

The formation of radioactive drugs was investigated by exposure of the pure compounds in a nuclear reactor. Probenecid (p-(dipropylsulfamyl)benzoic acid) was irradiated for 1 hr with a mixture of slow and fast neutrons ($\Phi = 2 \times 10^{13}$ n $cm^{-2}$ $sec^{-1}$), giving rise to the pure $\beta$ emitters $S^{35}$ and $P^{32}$ on the basis of the reactions $S^{34}(n,\gamma)S^{35}$ ($\sigma = 0.11$ barn) and $S^{32}(n,p)P^{32}$ ($\sigma = 0.19$ barn). A large proportion of the drug was decomposed during irradiation. The irradiated drug was dissolved in alkaline solution, filtered, and precipitated with HCl. The precipitate was shaken with various organic solvents, and repeatedly reprecipitated from acid and recrystallized. The procedure gave an 8% overall yield of analytically pure Probenecid from the irradiated products; it had a specific activity of ~12 μc/millimole (as $S^{35}$). Analytical purity was demonstrated by the criteria of the mixed melting point and chromatographic techniques; its properties were identical to those of the unirradiated drug. A slight radiochemical impurity, from $P^{32}$ in an unidentified compound present in trace amounts, could not be eliminated. When radioactive Probenecid was injected into the tail vein of rats, the relative distribution 30 min later in various organs was: kidney : liver : heart : skeletal muscle 100 : 27 : 12 : 12. By irradiation of the carbonic anhydrase inhibitor Diamox (5-acetamido-1,3,4-thiadiazole-2-sulfonamide) an analytically pure product was separated by a similar technique. The $S^{35}$-labeled drug was obtained in lower yield, however, than in the case of Probenecid. (H.H.D.)

**10684** APPLIED RADIATION CHEMISTRY: THE POSITION IN 1962. A. J. Swallow (Christie Hospital and Holt Radium Inst., Manchester, Eng.). Brit. Chem. Eng., 8: 27-31(Jan. 1963).

A review is given on the position of applied radiation chemistry. Discussion is given on fission products as radiation sources, use of machines, crosslinking of polythene and other polymers, industrial applications other than in the polymer field, and the use of fission fragment energy. (P.C.H.)

**10685** THE QUENCHING OF MERCURY RESONANCE RADIATION BY HYDROCARBONS: THE EFFECT OF DEUTERIUM SUBSTITUTION. Yves Rousseau and Harry E. Gunning (Univ. of Alberta, Edmonton). Can. J. Chem., 41: 465-9(Feb. 1963).

The effect of deuteration on the quenching cross section ($\sigma Q^2$) was determined for propane, cyclopropane, isobutane, and propylene. The results were as follows, with the $\sigma Q^2$ values, in $Å^2$, in parentheses: $C_3H_8$ (1.2); $CH_3CD_2CH_3$ (0.17); $CD_3CH_2CD_3$ (1.0); $C_3D_8$ (0.09); cyclo-$C_3D_6$ (0.29); $(CH_3)_3CH$ (4.8); $(CH_3)_3CD$ (0.44); $C_3H_6$ (29.8); and $C_3D_6$ (28.7). The deuterium isotope effect is most pronounced in the secondary C – H bonds of propane, and the tertiary C – H bond of isobutane. In the latter case, the isotope effect is estimated to be 15-16. For propylene, perdeuteration has little, if any, effect on $\sigma Q^2$, indicating that C – H bonds are not involved in quenching. Further implications of the results with respect to the quenching process are discussed. (auth)

**10686** THE QUESTION OF THE MECHANISM OF THE HYDROGEN PEROXIDE FORMATION IN THE RADIOLYSIS OF WATER. J. Bednář (Inst. for Physics, Czechoslovak Academy of Sciences, Řež). Collection Czech. Chem. Commun., 27: 2204-8(Sept. 1962). (In German)

The formation of hydrogen peroxide was followed in the radiolysis of aqueous sodium nitrate solutions from $1 \times 10^{-2}$ to 5M with $Co^{60}$ radiation. From the results obtained and from the results of previous writers on the radiolysis yield, it was found that the effect of the concentration of dissolved materials is noticeable in three different ranges, the limits of which can be determined through the velocity constants and type of reaction of the dissolved material with the radiolysis products. At concentrations of the material up to $10^{-2}$M the reactions in the radiation track remain untouched, and the total yield of the water radiolysis is constant. In the concentration range up to 1M the dissolved materials react with the primary radiolysis products in the track, and the yield of the water decomposition increases. For higher concentrations the yield of the water radiolysis is again constant. The yield of the water decomposition decreases because of the decreasing electron quota of the water. The decomposition yield of the dissolved material increase only through direct effect of the radiation on the dissolved material. (tr-auth)

**10687** SENSITIZED FORMATION OF AROMATIC AMINE ION RADICALS DURING RADIOLYSIS OF FROZEN TRANSPARENT ORGANIC SOLUTIONS. Kh. S. Bagdasar'yan, and Z. A. Sinitsyna (Karpov Inst. of Physics and Chemistry, [Moscow]). Doklady Akad. Nauk SSSR, 147: 1396-8(Dec. 21, 1962). (In Russian)

It was found that cation radicals of amines are formed on irradiating a film of methyl methacrylate containing a small amount of amine at liquid nitrogen temperatures. On irradiating a transparent, frozen organic solution containing 0.005 mol/l of diphenylamine, a blue-green compound was formed with an absorption maximum at 670 mμ. The optical density was proportional to the dose up to $7 \times 10^{18}$ ev/g, and then remained constant with a further increase in dose. The color disappeared rapidly on thawing with emission of a blue fluorescence. A limiting concentration of cation amine radicals was attained that could not be increased by increasing the dose or raising the concentration of amine in the irradiated solution. The limiting concentration of triphenylamine cation radicals was a factor of 100 greater in polymethacrylate than in hydrocarbon solvents. It was assumed that electrons are trapped by the ethoxy group of the methyl methacrylate molecule, and that the amine can thus react with the substrate. The limiting con-

centration of cation radicals was attained at a dose of $7.3 \times 10^{18}$ ev/g, and an amine concentration of 0.005 moles/l. The G yield of cation radicals was 0.16. It was found that $CCl_4$ also increases the yield of cation radicals on irradiating diphenylamine. (TTT)

**10688** PLASTIFICATION OF POLYETHYLENE BY LOW-TEMPERATURE RADIOLYSIS. V. G. Nikol'skii and N. Ya. Buben (Inst. of Physics and Chemistry, Academy of Sciences, USSR). Doklady Akad. Nauk SSSR, 147: 1406-8 (Dec. 21, 1962). (In Russian)

High-pressure polyethylene disks 10 mm in diameter and 2 mm thick were irradiated at a temperature of 77°K with fast electrons at doses of 1 to 70 million rads. The samples were heated at a constant rate, and the luminescence due to the recombination of active centers formed by the irradiation was recorded by a photomultiplier. The luminescence maximum at 233°K, which corresponds to the transition of polyethylene to an elastically plastic state, decreased from 230°K at a dose of $1 \times 10^6$ rads to about 190°K at a dose of $70 \times 16^6$ rads. A sample irradiated with a dose of $20 \times 16^6$ rads at 77°K was heated to 300°K, and then cooled to 77°K and reirradiated with a dose of $1 \times 10^6$ rads. The resulting luminescent curve was similar to that obtained with a sample irradiated at 77°K with a dose of $1 \times 10^6$ rads. The plastification of the polyethylene was due to the formation of hydrogen and other low-molecular-weight hydrolysis products (hydrocarbons). If the heating rate on thin, irradiated polyethylene samples was decreased from 40 to 50° per minute to 5° per minute, no difference in melting points could be observed for samples given doses of 0.5 and 4 million rads respectively. With the low-temperature irradiation of polyethylene, cross-linking reactions tended to raise the melting point, but the gaseous radiolytic products tended to decrease the melting point. (TTT)

**10689** STUDY OF THE COOLANT-MODERATOR ORGANIC FUELS OF REACTORS. RADIOLYTIC AND THERMAL STABILITY OF TERPHENYLS. A. Houllier and J.-R. Puig. Energie Nucl., 4: 343-51(Sept.-Oct. 1962). (In French)

The terphenyls have chemical and physical properties that are favorable with respect to their use as coolants and moderators in nuclear reactors. The thermal stability of terphenyls was studied in the temperature range from 416 to 525°C, and their behavior under radiation was investigated at temperatures from 300 to 400°C. The tests were made on ampulses. The thermal and radiolytic behavior of p-terphenyls was examined and compared with that of other isomers and commercial products. (tr-auth)

**10690** RADIATION PROTECTION IN AQUEOUS POLYMER SOLUTIONS. A. Charlesby and P. M. Kopp (Royal Military Coll. of Science, Shrivenham, Eng.). Intern. J. Radiation Biol., 5: 521-34(Oct. 1962).

Water-soluble polymers (polyvinylpyrrolidone and polyethyleneoxide) can be cross-linked by irradiation when present in aqueous solutions. A study of the gelation dose versus concentration indicates little contribution from the indirect effect (due to energy absorbed in the water) in the range from 1% to 65% for polyvinylpyrrolidone K.35 and from 0.5% to 10% for polyethyleneoxide WSR.35. The gelation dose is greatly modified by the presence of various small amounts of certain additives. The relationship between the degree of protection (i.e. the relative increase in gelation dose) and the additive concentration was studied for various additives at different concentrations. It was found that the gelation dose increases with additive concentration and protection occurs up to a limiting concentration and is then unaffected by a further increase in additive concentration. Values are given of the protection offered by a wide range of additives of the two types. Many additives are distinguished by the presence of sulfur in their structure. In the presence of oxygen the gelation dose is increased. This is not a true protection effect and is not affected by the additive. A few comparisons can be made between the effect of some additives in polymer solutions and in protection experiments with mice. Further investigations are in progress to study the fate of the protecting additives. (auth)

**10691** ISOTOPES IN THE CHEMISTRY OF ELASTOMERS. P. Krumbiegel (Institut für Physikalische Stofftrennung, Lepzig). Isotopen Tech., 2: 282-5(Sept. 1962). (In German)

The rapid development of the chemistry of rubber has brought many new questions with it. Some of these problems can be solved by the utilization of stable or radioactive isotopes. Previously published works are reviewed especially to find places for the further application of stable isotopes. Only those works were considered in which the isotopes of hydrogen, carbon, nitrogen, oxygen, or sulfur were used for labeling. (tr-auth)

**10692** THE RADIOLYSIS OF FERRO- AND FERRICYANIDE SOLUTIONS. G. Hughes and C. Willis (The University, Liverpool). J. Chem. Soc., 4848-53(Dec. 1962).

The oxidation of potassium ferrocyanide in dilute sulfuric acid solution by $\gamma$ radiation was investigated and compared with that of ferrous sulfate. Significant differences between the two systems are discussed. (auth)

**10693** RADIOLYSIS OF AQUEOUS SOLUTIONS OF TELLURIUM BY $\gamma$ RAYS. I. STUDY OF ALKALINE SOLUTIONS. RADICAL AND MOLECULAR YIELDS. M. Haïssinsky and P. Patigny (Université Paris). J. Chim. Phys., 59: 675-80(July-Aug. 1962). (In French)

The radiolytic oxidation of tetravalent tellurium, in concentration from $10^{-4}$ to 1M, was studied in 0.2N NaOH solution under oxygen or after degassing. A mechanism was proposed for the reactions produced in dilute solution; it leads to the following values for the radical and molecular yields in this medium: $G_H = 2.75$; $G_{OH} = 3.15$; $G_{H_2} = 0.30$; $G_{H_2O_2} = 0.10$; and $G_{-H_2O} = 3.35$. The formation of elementary Te in the concentrated solutions is attributed to a direct effect of the radiation. (tr-auth)

**10694** RADIOCHEMICAL POLYMERIZATION OF BIS(CHLOROMETHYL)-3,3-OXETANE IN THE SOLID STATE. Adolphe Chapiro and Stanislas Penczek (Centre National de la Recherche Scientifique, Bellevue, France). J. Chim. Phys., 59: 696-702(July-Aug. 1962). (In French)

Bis(chloromethyl)3,3-oxetane is not polymerized when it is irradiated in the liquid state. On the contrary, the irradiation of the solid monomer leads to a very rapid polymerization that has a direct relation with temperature. All the conversion curves have an induction period followed by an acceleration. When the conversion is represented as a function of the logarithm of time, curves having an important linear portion are obtained. After a certain conversion, generally between 5 and 15%, the results are poorly reproducible and the reaction is sometimes completely arrested. The polymerization is more rapid and the polymer mass is higher when the monomer is slowly crystallized and is present in the form of large crystals. The relation between the velocity and the intensity of the radiation is very complex; the intensity exponent decreases regularly with the latter. The activation energy of the reaction is 3.0 kcal/mol between −78 and 15°C. The reaction is not affected by the classical inhibitors of radical reactions. The results are discussed within the framework of actual knowledge on

radiochemical polymerization of heterocyclic monomers. (tr-auth)

**10695** INTERPRETATION OF ELECTRON PARAMAGNETIC RESONANCE SPECTRA OF SOLID IRRADIATED FORMALDEHYDE. Claude Chachaty and Rose Marx (Faculté des Sciences, Orsay, France). J. Chim. Phys., 59: 792-4(July-Aug. 1962). (In French)

The EPR spectrum of formaldehyde irradiated at −196°C was interpreted from the spectra obtained by irradiating polyformaldehyde at low temperatures (−196°C) and at room temperature (20°C). The results can be explained by the reaction of the radical $H-C^{\bullet}$ with formaldehyde, which

$$\begin{matrix} & \| \\ & O \end{matrix}$$

gives the increasing chain radical $\sim\!O-CH_2^{\bullet}$ which is isomerized into $\sim\!O-\underset{\bullet}{C}H-O-CH_3$. (tr-auth)

**10696** CHEMICAL EFFECTS OF $Co^{60}$ $\gamma$ RAYS ON AQUEOUS SOLUTIONS OF GOLD CHLORIDE. I. REDUCTION OF CHLOROAURIC ACID AT pH 2.8. EFFECT OF CHLORINE IONS. Anne-Marie Koulkes-Pujo and Stanislas Ziemecki (Institut du Radium, Paris). J. Chim. Phys., 59: 843-9(Sept. 1962). (In French)

The effect of pH and the presence of chlorine ions on the reduction of chloroauric acid by $\gamma$ radiolysis were investigated. The methods used for the determination of Au(III) and $H_2O_2$ were described. The results show that the radiolytic reduction yield of 2.3 ± 0.2 for gold chloride is equal to that obtained by irradiation of various other solutes that are reduced by radiations. Extrapolation to zero concentration in $Cl^-$ yields G−Au(III) = 2.15 at pH 2.8, which permits $G_H - G_{OH}$ to be calculated as 0.62. In acid or neutral media, this difference is 0.84 and 0.6, respectively. The presence of a solid phase does not disturb the reactions usually produced in a homogeneous phase. In the presence of excess $Cl^-$, there is no reduction, probably because the hydrogen peroxide does not react with Au(III) and because $G_{Cl}$ is higher than $G_H$. For Au(III) concentrations $\geq 1.6 \times 10^{-2}$ M, the $Cl^-$ ions contribute to the decrease of the reduction yield, but their effect is less important than in acid medium on the $Ce^{4+}-Ce^{3+}$ system. It is suggested that this is the result of a pH effect either on the state of the OH radicals or on the reaction of the OH radicals with $Cl^-$. (tr-auth)

**10697** URANYL SENSITIZED PHOTODECOMPOSITION OF ORGANIC ACIDS IN SOLUTION. G. E. Heckler, A. E. Taylor, C. Jensen, D. Percival, R. Jensen, and P. Fung (Idaho State Coll., Pocatello). J. Phys. Chem., 67: 1-6 (Jan. 22, 1963).

Uranyl sensitized photodecomposition products of various organic acids are presented. Sensitized photodecomposition rates for malonic, succinic, and glutaric acids were determined in the pH range 0.5 to 3.0 by measuring the gas produced in a Warburg micromanometric apparatus. Theoretical analysis of the results showed that the photosensitive species is a 1:1 complex of diionized acid with uranyl ion for malonic acid and a mixture of 1:1 complex and 2:1 complex of monoionized acid with uranyl ion for succinic and glutaric acids. (auth)

**10698** THE FORMATION OF BENZENE IN THE RADIOLYSIS OF ACETYLENE. Gilbert J. Mains, H. Niki, and M. H. J. Wijnen (Carnegie Inst. of Tech., Pittsburgh and Mellon Inst., Pittsburgh). J. Phys. Chem., 67: 11-16 (Jan. 22, 1963). (RRL-77; NYO-10156)

The radiolysis of acetylene was studied over the pressure range 10 to 300 mm and over the temperature range 25 to 262°. The effects of small amounts of free radical scavengers, the effects of excess krypton, and the effects of an excess of mercury vapor on the radiolysis yield of benzene were studied. $C_2H_2:C_2D_2$, $C_2H_2:D_2$, and $C_2D_2:H_2$ mixtures also were subjected to radiolysis. One experiment on the mercury photosensitized formation of benzene in a $C_2H_2:C_2D_2$ mixture is reported. The data are shown to be consistent with the formation of benzene by free radical reactions. A possible free radical mechanism to explain the formation of benzene and intermediate products is discussed. (auth)

**10699** RADIOLYSIS OF LIQUID METHANOL AND SOME METHANOLIC SALT SOLUTIONS. Leslie M. Theard and Milton Burton (Univ. of Notre Dame, Ind). J. Phys. Chem., 67: 59-64(Jan. 22, 1963).

In the concentration range $10^{-3}$ to $10^{-1}$ M, KI decreased yields of glycol and of $H_2$ and increased formaldehyde yield in $Co^{60}$-gamma radiolysis of liquid methanol according to the stoichiometric relationship $-\Delta G(\text{glycol}) + \Delta G(H_2) \simeq \Delta G(H_2CO)$. CsCl has similar but less pronounced effects and KBr and KCl are without effect. The chlorides of La, Gd, Dy, Y, and Lu, at concentrations >0.05 M, have effects on G(glycol), and $G(H_2CO)$ that are qualitatively similar to that of KI (changes in $G(H_2)$ are attributable to an acid effect); effects within the group differ quantitatively in a manner independent of atomic number or magnetic character (paramagnetic or diamagnetic). The effects of the salts other than KI are discussed in terms of the influence of degree of solvation. The effect of KI on G(glycol) and $G(H_2CO)$ is concluded to be attributable to the chemistry of the $I^-$ ion itself and to be non-dependent on its mass or atomic number as such. The important mode of behavior that leads to $H_2CO$ enhancement and equal glycol decrease is suggested to be $CH_3O + I^- \rightarrow CH_3O^- + I$. (auth)

**10700** RADIOLYTIC AND THERMAL DECOMPOSITION OF BORAZOLE. Clarence J. Wolf and Richard H. Toeniskoetter (Union Carbide Corp., Parma, Ohio). J. Phys. Chem., 67: 88-91(Jan. 22, 1963).

The hydrogen yield from the $Co^{60}$ $\gamma$ radiolysis of borazole was constant ($G(H_2) = 0.36$) from −196 to −120° and then increased to 2.90 at 30°. Diphenylpicrylhydrazyl scavenger experiments indicated a yield of 7.5 ± 0.5 radicals per 100 ev absorbed. At 24°, borazole decomposed thermally, producing hydrogen at a rate of $4 \times 10^{-3}$ moles/l-sec for 24-hr periods. The decomposition reaction at 30.8 and 40.8° appeared to be autocatalytic since the rate of hydrogen production increased with time. (auth)

**10701** RADIATION DOSE AND IODINE SCAVENGER EFFECTS ON RECOIL $C^{11}$ REACTIONS IN CYCLOHEXANE. Edward P. Rack and Adolf F. Voigt (Iowa State Univ., Ames). J. Phys. Chem., 67: 198-200(Jan. 22, 1963).

Studies were made on the reaction between $C^{11}$ and cyclohexane in which the ($\gamma$,n) reaction was used as the method of activation. The relative yields of gaseous products were determined as a function of the radiation dose and of the concentration of iodine dissolved in the cyclohexane. The results show that radioinduced portions of the yields of $CH_4$, $C_2H_4 + C_2H_6$, and $C_3H_6$ are removed by iodine and hence involve species that react with iodine. The portion of yields produced at zero dose or in the presence of iodine was considered as the true hot-atom yield, resulting from the fact that the $C^{11}$ fragment has energy above that of its surroundings. Ion-molecule reactions were eliminated. The various products appeared to be formed predominantly by reactions of the recoiling fragment with the molecules of cyclohexane. (P.C.H.)

**10702** USE OF AN ELECTRIC FIELD TO SEPARATE THE RECOIL PRODUCTS OF (n,$\gamma$) REACTIONS IN BROMINE AND IODINE. H.-J. Arnikar (Univ. of Poona, India). J. Phys. Radium, 23: 578-9(Aug.-Sept. 1962). (In French)

A study was made to determine the effects of the chemical nature of an irradiated liquid, the polarity of the collecting

electrode, and isotopic effects on the separation by an electric field of the (n,γ) recoil products. The studies were made on $C_6H_5Br$, $C_2H_5I$, and on iodine dissolved in $CCl_4$ or $C_6H_6$. After irradiation an electric current was applied between two silver electrodes placed in the liquid for 15 min. The activity deposited on the electrodes were measured. The results are tabulated and lead to the following conclusions. In phenyl bromide and ethyl iodine almost 30% of the total activity produced can be separated. The yield on the anode, in the case of bromine is 2 to 4 times that on the cathode. No activity was observed on the electrodes after the irradiation of iodine dissolved in $CCl_4$ or $C_6H_6$. Isotopic effects were observed for bromine. The possible secondary reactions from the irradiation are discussed. (J.S.R.)

**10703** EFFECT OF POLONIUM α RADIATION ON GELATINE. Marie Ader (Collège de France, Paris). J. Phys. Radium, 23: 590-1(Aug.-Sept. 1962). (In French)

When a nuclear plate, which has been exposed to radiation, developed, and dried, is exposed to a Po source, no effect can be detected by either the eye or the microscope. However if the plate is placed in distilled water, the emulsion thickness of the irradiated region is reduced by approximately 20μ. A "ridge" separates this region from the nonirradiated region. The ridge contains piles of silver grains, very deformed traces of the old radiation, and some gelatin fragments. It appears that the α particles penetrating the gelatine transforms this gelatin, reversible protein, into a substance "soluble" in distilled water or entrained by the distilled water. (J.S.R.)

**10704** THE EFFECT OF IONIZING RADIATION ON THE SYNTHESIS OF HYDROCYANIC ACID. R. Mikhail and I. Gershkovich (Inst. of Chemical Research, Bucharest). Kinetika i Kataliz, 3: 836-45(Nov.-Dec. 1962). (In Russian)

Radiation effects on the synthesis of hydrocyanic acid from methane and ammonia, in the presence or absence of oxygen, on platinum catalysts were studied. Radiation was found to influence the reaction at high temperatures. (tr-auth)

**10705** THE EFFECT OF TEMPERATURE AND DOSE RATE ON RADIOLYSIS AND RADIATION-INDUCED OXIDATION OF DIISOPROPYL ETHER. V. V. Saraeva, N. A. Bakh, V. I. Dakin, and P. Dillinger (Moscow State Univ.). Kinetika i Kataliz, 3: 865-9(Nov.-Dec. 1962). (In Russian)

Radiolysis in the absence of oxygen produced simultaneously linked carbonyl compounds and alcohol compounds. At low temperatures and in the presence of oxygen, peroxides and unlinked carbonyl compounds are formed, while at higher temperatures (over 10°C) linked peroxide and carbonyl compounds with 15 and 20 kcal/mole activation energies are formed. (tr-auth)

**10706** ON THE ENRICHMENT OF RADIOACTIVE CESIUM SOLUTIONS BY THE FOAMING METHOD. L. D. Skrylev and V. V. Pushkarev (Ural Kirov Polytechnic Inst., Sverdlovsk, USSR). Kolloidn. Zh., 24: 738-41(Nov.-Dec. 1962). (In Russian)

Soluble mixed heavy metal ferrocyanides, formed with difficulty in the reaction of heavy metal salts with potassium ferrocyanide, can be used as sorbents of radioactive cesium. An essential shortcoming of such compounds is their easy peptizability by excess precipitant (potassium ferrocyanide ions), making it impossible to separate the solid and liquid phases by the ordinary methods of filtration, centrifugation, or settling. The foaming method is suggested for extracting mixed ferrocyanides from the radioactive solutions undergoing treatment. The method allows not only the formed precipitates, but also colloids to be removed from the solution. The possibility of enriching radioactive $Cs^{134}$ solutions by sorption of its precipitates with mixed di- and trivalent iron ferrocyanides followed by removal of the solid phase with the aid of the foaming method is elucidated. (P.C.H.)

**10707** IONIZATION OF THE HYDROGEN ATOM CLOSE TO THE THRESHOLD. V. Veldre, E. Iolin, and E. Karule (Inst. for Physics, Academy of Sciences, Latvian SSR). Latvijas PSR Zinatnu Akad. Vestis, No. 6, 67-71(1962). (In Russian)

The solution of the problem for the ionization of the hydrogen atom under electron bombardment can be reduced to the solution of a system of integro-differential equations. Only s-waves of the electrons were considered and only in the approximation of weak coupling. The ionization was examined close to the barrier, i.e., where the electron energy is less than 18 or 19 ev. This enabled Bessel functions to be used instead of Coulomb wave functions. The formula was derived for the effective ionization cross section and in addition, the approximation was considered when sin ks approaches ks, where k is the momentum of the released electron. The calculations were carried out on an electronic computer BESM-2 and the results are displayed graphically. The results were compared with those calculated using Coulomb wave functions and it was found that for less than 16 ev the relative error is only 10%, while for 16 to 19 ev it is 19%. This relative difference decreased even more when the sin ks → ks approximation was considered. (TTT)

**10708** A STUDY OF THE EFFECT OF HIGH ENERGY IRRADIATION UPON THE INTERNAL MOTION OF POLYETHYLENE BY PULSED NMR METHOD. Takao Kawai. Mem. Coll. Sci., Univ. Kyoto, Ser. A, 30: 29-37(Aug. 1962). (In English)

The internal motions of both the unirradiated and the irradiated polyethylene were investigated by measuring the spin-lattice relaxation-time ($T_1$) inclusive of its minima ($T_{1min}$) of proton in the temperature range from liquid nitrogen up to about 300°C by pulsed NMR (nuclear magnetic resonance) method at 25 Mc/sec. For the unirradiated polyethylene, two minima of $T_1$ were observed: one at the higher temperature corresponding to the internal motion in the crystalline region, and the other at the lower temperature corresponding to the internal motion in the amorphous region of the sample. For the irradiated polyethylene, the increase in the value of $T_1$ and the flat V-shaped curve were observed at the comparatively weaker irradiations. For stronger irradiations, however, the value of $T_1$ decreased and only a single $T_{1min}$ was observed. These results can be qualitatively explained by the effects of both the cross-linkings and the loss of crystallinity by irradiation. (auth)

**10709** THE EFFECTS OF γ-IRRADIATION ON CARBON TETRACHLORIDE SOLUTIONS OF POLYISOBUTYLENE AND POLYSTYRENE. Bunzo Eda and Tasuo Matsuda. Nagoya Kogyo Gijutzu Shikensho Hokoku, 11: 189-92(Mar. 1962). (In Japanese)

Carbon tetrachloride, because of its large G-value, was used as the solvent in studying whether the effects produced in polymers were direct or indirect. Since the solution concentration is important for this purpose, polyisobutylene solutions of 0.2, 0.4, 0.8, and 1.6% were irradiated with a 300-c $Co^{60}$ source in the absence of air at a dosage rate of 0.05 Mr/hr at 30 ± 2°C up to 0.98-4.39 Mr. Similarly, polystyrene solutions of 0.4, 0.8, and 1.2% were irradiated with a 3000-c $Co^{60}$ source at the rate of 0.36 Mr/hr up to 2.2 to 6.7 Mr. A considerable decrease in molecular weights was observed in all cases. For polyisobutylene, degradation

became more rapid in dilute solutions than in the solid state and increased with increasing dilution. Hence, it was concluded that its main chain scissions were due to the indirect action by the free radicals formed in the solvent. On the other hand, the degradation of polystyrene solutions was not affected by concentrations, and it was concluded that this was the result of the direct radiation effect. (OID)

**10710** INORGANIC ION-EXCHANGE RESINS COULD PURIFY HOTTER REACTOR WATER. Norman Michael, Robert F. Sterling, and Paul Cohen (Westinghouse Electric Corp., Pittsburgh). Nucleonics, 21: No. 2, 62-4(Feb. 1963).

Hydrous zirconium phosphate and hydrous zirconium oxide were used for intensive evaluation. Ion-exchange properties of the materials related closely to structure. Firing at 300°C for 16 hr obtained the desired physical properties. With optimum preparation the resistance to attrition by 310°C water was acceptable. The mechanism for pickup of these substances was one of complexing or chemisorption rather than exchange. (C.E.S.)

**10711** CONNECTION BETWEEN F- AND M- CENTERS IN KCl AFTER ROENTGEN RADIATION AT ROOM TEMPERATURE. K. Thommen (Universität, Bonn). Phys. Letters, 2: 189-90(Sept. 15, 1962). (In German)

Measurements were made of the relation between F and M center concentration in irradiated KCl crystals. Data are presented in graph form. The results indicated that M centers were both formed and destroyed by x radiation. It appeared that there is a dynamic temperature-dependent equilibrium between F centers and M centers, whose standardization the radiation strongly accelerated. (M.C.G.)

**10712** ROENTGEN- AND $\beta$-LUMINESCENCE OF SILVER CHLORIDE CRYSTALS. J. Beneš (Inst. of Nuclear Physics, Czechoslovak Academy of Sciences, Prague), Z. Berger, A. Janoušek, K. Vacek, and E. Vavřinec. Phys. Status Solidi, 3: 52-4(1963). (In German)

Measurements were made of the spectral dependence of luminescence excitated in AgCl crystals by x radiation (with two different excitation energies) and $\beta$ rays. The results were compared with the spectra obtained by uv radiation. Two bands were observed, of which the short wavelength band was in agreement with the same band obtained by uv radiation, whereas the long wavelength band was shifted towards shorter wavelengths with increased excitation energy as compared to that obtained by uv light and was split into two bands by excitation with $\beta$ rays. The luminescence mechanism is supposed to be associated with two different centers just as in the case of uv excitation, but only those centers corresponding to the short wavelength band can be equal for both modes of excitation. (auth)

**10713** MONOMOLECULAR SOURCE $P^{32}$. I. I. Badenko and V. G. Fleisher (Inst. of Physics and Tech., Academy of Sciences, USSR). Pribory i Tekhn. Eksperim., No. 5, 179-80(Sept.-Oct. 1962). (In Russian)

Preparation of a monomolecular $P^{32}$ source is based on the surface-active organic compounds' ability to develop monolayers on an aqueous surface. (tr-auth)

**10714** ON THE PREPARATION OF THE NEUTRON-DEFICIENT $Nb^{92}$ IN HIGH SPECIFIC ACTIVITY. K. P. Gopinathan (Tata Inst. of Fundamental Research, Bombay). Proc. Indian Acad. Sci., Sect. A, 56: 262-8(Nov. 1962).

The extraction of niobium by di-isobutyl ketone from hydrochloric acid solutions is investigated. This method is made use of in the preparation of the neutron-deficient $Nb^{92}$ in high specific activity. $Nb^{92}$ is produced by (n,p) reaction in $Mo^{92}$ using natural molybdenum irradiated in the reactor. The effect of (n,p) reactions in other naturally present isotopes of molybdenum, on the radiochemical purity of the sample, is discussed. (auth)

**10715** CHLORINATION OF SILICON-CONTAINING MONOMERS AND POLYMERS UNDER THE EFFECT OF GAMMA-RADIATION. R. V. Dzhagatspanyan, V. I. Zetkin, G. V. Motsarev, and M. T. Filippov. Radioaktivn. Izotopy i Yadernye Izlucheniya v Nar. Khoz. SSSR, Tr. Vses. Soveshch., Riga, 1960, 1: 197-200(1961).

Polydimethylsiloxane rubber (I) and polyphenylmethylsiloxane (II) as well as a number of monomers were chlorinated at 0°C under the action of $\gamma$-radiation ($Co^{60}$ with an activity of 1400 g-equiv of Ra). Chlorination of I took place easily and rapidly until the introduction of an average of two Cl atoms into the chain of the polymer, after which the process rate fell sharply. In a metal autoclave at both 0 and 60°C, destruction of the polymer took place. With chlorination of II (molar ratio of Cl : siloxane = 2 : 1 and 3 : 1) substitution and addition chlorination took place in the aromatic ring. With chlorination of $(CH_3)_3ClSi$ (molar ratio of $Cl_2$ : silane = 0.51 : 1) the basic product was a monochlorine derivative; chlorination of 18.6 g of ethyl-trichlorosilane (molar ratio of $Cl_2$ : silane = 0.35 : 1) gave 6.5 g of $\alpha$ and $\beta$-chloroethyl-trichlorosilanes. Chlorination of methyl-phenyl dichlorosilane resulted in the formation of $(C_6H_2Cl_3)(CCl_3)SiCl_2$ (b. p. 185-188/10 mm). (Referativnyy zhurnal. Khimiya, No. 12, 1962)

**10716** THE $\gamma$ RADIOLYSIS OF LIQUID CHLOROBENZENE. J. Wendenburg and A. Henglein (Hahn-Meitner-Institut für Kernforschung, Berlin). Z. Naturforsch., 17b: 590-7(Sept. 1962). (In German)

Chlorobenzene is decomposed by Co-60 $\gamma$ radiation with a total yield of 7.0 ± 0.5 molecules per 100 ev. This yield decreases with increasing dose. 50% conversion is observed at a dose of $10^9$ rads. At least 25% of the molecules consumed are converted by a molecular mechanism which cannot be inhibited by iodine. Primary radical formation by the dissociation $C_6H_5Cl \rightarrow C_6H_5\cdot + Cl\cdot$ occurs with G = 1.8. At an average, each of the generated radicals and atoms attacks one intact molecule of chlorobenzene to form benzene (G = 2.4), hydrogen chloride (G = 1.4), and some secondary free radicals. These combine or disproportionate to give the isomers of dichlorobenzene (G = 0.23), dichlorodiphenyl, and chlorodiphenyl (G = 1.0). One of their main products is a tetramer (G = 1.5 base units/100 ev) which could be separated by precipitation with methanol. It contains 1.28 chlorine atoms per $C_6$ ring and several olefine double bonds when formed at low doses. At higher doses its chlorine contents increases up to 1.9 atoms/$C_6$ ring since the double bonds are able to add the hydrogen chloride formed. The isomers of chlorodiphenyl are formed in the abundance ratio which is expected from statistical considerations of free phenyl radical addition to chlorobenzene. The isomers of dichlorobenzene are formed in a ratio which is between that of the statistical distribution and that known from the chlorination of chlorobenzene in the presence of $AlCl_3$. (auth)

**10717** THE EFFECT OF OH RADICALS AND H ATOMS IN DILUTED AQUEOUS SOLUTIONS OF INORGANIC SALTS IN COMPARISON WITH THAT OF X RADIATION. Hermann Engelhard and Friedrich Wilhelm Froben (Universität Gottingen, Ger.). Z. Naturforsch., 17b: 639-46(Oct. 1962). (In German)

The OH radicals occurring in a high-frequency discharge in water vapor have as their secondary products an oxidation of Fe(II) and hexacyanoferrate(II) and a reduction of Ce(IV), and hexacyanoferrate(III), whereas H atoms from the water vapor discharge reduced hexacyanoferrate(III),

Au(III) and Ag(I). These results were compared with x-ray investigations and the reaction equations were discussed. The reactions velocities and G values in aqueous solutions were given (also for the water cleavage). The redox potential of the H atoms is smaller than +0.36 v and that of OH radicals is between +0.8 and +1.4 v. (tr-auth)

**10718** EFFECT OF IONIZING RADIATION ON AQUEOUS SOLUTIONS OF VITAMIN $B_{12}$. H. Herzmann and A. Hennig (Deutsche Akademie der Wissenschaften, Berlin). Z. Naturforsch., 17b: 646-54(Oct. 1962). (In German)

The decomposition of $Co^{58}$-labeled vitamin $B_{12}$ as a result of self irradiation was investigated and the dose output of the aqueous solution was calculated. At a radioactive concentration of 3.0 mC/21 ml the absorbed doses were $D_\gamma$ = 6050, $D_{\beta^+}$ = 3310, and $D_K$ = 900 rad/D, altogether 10,260 rad/D. The total dose corresponding to a half-value time is 533,000 rad. The decomposition was followed by paper chromatography, electrophoresis, and bacteriology. Solutions of labeled and unlabeled vitamin $B_{12}$ exposed to external $Co^{60}$ radiation were also used in the investigations. The relation between the modification of the absorption spectra, the decrease of the biological efficiency, and the increase of the radioactive impurities with absorbed dose was derived. Various substances were tested for the protection of aqueous labeled vitamin $B_{12}$ solutions. Of these ethanol was especially suitable. (tr-auth)

**10719** INFLUENCE OF THE EXCHANGING ION AND THE DEGREE OF CROSSLINKAGE OF DVB ON THE RADIATION STABILITY OF ION EXCHANGER RESINS. E. D. Kiseleva, K. V. Chmutov, and V. N. Krupnova (Inst. of Physical Chemistry, Academy of Sciences, USSR). Zh. Fiz. Khim., 36: 2707-13(Dec. 1962). (In Russian)

The radiation stability of ion exchangers was investigated in relation to the charge and radius of the hydrated exchange ion. Particular attention was given to the properties of an irradiated resin in variable valency ion forms. It was shown that irradiation of the resin in the $Fe^{3+}$, $Cu^{2+}$, $Cr^{3+}$, and $UO_2^{2+}$ forms stabilizes the C—S bond, but at the same time there is an increase in breaking of the C—C bonds in the cross bridges. There is no considerable diminishing in the $-SO_3H$ capacity of the irradiated resin but swelling increases. The properties of the irradiated sorbents of a second resin in the $Fe^{3+}$, $Cu^{2+}$, $Cr^{3+}$, and $UO_2^{2+}$ forms change in the same manner as the irradiated $H^+$ form. Irradiation of both resins in the $Fe^{3+}$, $Cu^{2+}$, $Cr^{3+}$, and $UO_2^{2+}$ forms as in the $H^+$ form causes the appearance of new exchange groups with pK = 7.5 for one and 6.6 for the other. The effect of the ionizing radiation of a flow of fast electrons upon one of the resins with varying degrees of DVB crosslinkage was also investigated. Changes were observed in the capacity, swelling, and selectivity of $K_H^{Cs}$. Increase in the crosslinkage of DVB in the resin somewhat stabilizes the C—S bond. The appearance of new exchange groups with pK = 8 in the electron-irradiated resin with varying degrees of crosslinkage was observed by potentiometric titration. (P.C.H.)

**10720** ACTIONS CHIMIQUES PROVOQUÉES PAR LES PROCESSUS ET LES RAYONNEMENTS NUCLÉAIRES. (Chemical Actions Caused by Nuclear Processes and Radiations). M. Haissinsky. Thesis, Paris, Universite, 1960. 25p.

The nuclear processes and radiations that induce chemical reactions are reviewed. Recoil phenomena and rearrangement of the electron shell are described, and the chemical reactions induced by each type of nuclear process are discussed. The formation of free radicals by ionization and excitation is considered. In conclusion, the practical aspects of such nuclear-induced chemical reactions are indicated. (J.S.R.)

**10721** TRUDY II VSESOYUZNOGO SOVESHANIYA PO RADIATSIONNOI KHIMII. (Proceedings of the Second All-Union Conference on Radiation Chemistry, Moscow, October 10-14, 1960). L. S. Polak, ed. Moscow, Publishing House of the Academy of Sciences, 1962. 756p.

One-hundred-thirty-nine papers are included on radiation chemistry in USSR. The papers deal with the theoretical problems in radiochemistry, radiation effects on aqueous solutions and organic substances, radiation polymerization, and effects of radiation on polymers and solids. The investigation methods and procedures in radiochemistry are discussed. (R.V.J.)

**10722** RADIOLIZ UGLEVODORODOV. NEKOTORYE FIZIKO-KHIMICHESKIE PROBLEMY. (Radiolysis of Hydrocarbon. Some Physico-chemical Problems. A. V. Topchiev, ed. Moscow, Publishing House of the Academy of Sciences, 1962. 208p.

A survey is given of the physical and chemical problems in hydrocarbon radiolysis. Kinetics, free radicals, energy transmission, alkane adsorption on oxide catalyst, and radiation thermal cracking are discussed. (R.V.J.)

## Raw Materials and Feed Materials

**10723** (HW-SA-2433) THE APPLICATION TO A $UO_3$ CALCINER FURNACE OF A CLOSED LOOP CONTROL SYSTEM DEVELOPED USING SIMULATION TECHNIQUES. C. E. Huck (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Apr. 9, 1962. Contract AT(45-1)-1350. 31p.

An exact mathematical model was derived for a $UO_3$ calciner furnace system by use of analog computer simulation techniques. Closed loop tests, of the simulated model controlled by a simulated controller, determined the controller mode settings for stability and minimum error during system upsets, and for minimum overshoot at start up. Actual performance of the installed furnace control system was better than predicted by the analog tests. (auth)

**10724** VERTICAL INTEGRATION IN THE NUCLEAR FUEL INDUSTRY. Alan F. Lowell. Can. Nucl. Technol., 2: 17-19(1963).

Several unusual features of uranium mining as a business were stressed. Upward vertical integration from the crude yellow cake stage to the nuclear pure stage was shown to pose no great problems. The economic savings to the buyer as well as the refiner were considered and were very significant. (C.E.S.)

**10725** REDUCTION OF URANIUM TRIOXIDE WITH AMMONIA. V. G. Vlasov and V. M. Zhukovskii (Kirov Ural Polytechnic Inst., USSR). Kinetika i Kataliz, 3: 882-6(Nov.-Dec. 1962). (In Russian)

Kinetics of $UO_3$ reduction with ammonia at 300 to 425°C and 10 to 600 mm Hg was studied, and equation was derived for the reduction rate as a function of pressure. The apparent activation energy was determined. It is shown that molecular nitrogen desorption from the oxide surface is the limiting stage. (tr-auth)

**10726** EFFECTS OF ADDITIVE OXIDES ON $UO_3$ REDUCTION WITH DECOMPOSED AMMONIA. V. G. Vlasov and V. M. Zhukovskii. Zh. Prikl. Khim., 35: 1888-93 (Sept. 1962). (In Russian)

ZnO and TiO admixtures accelerate and $UO_{2.04}$ inhibits $UO_3$ reduction by nitrogen-hydrogen mixtures (decomposed ammonia). The mechanism of oxide admixture influence on free electron concentration in a reduced $UO_3$ conductance zone is discussed. (R.V.J.)

## Separation Processes

**10727** (BNL-6099) THE SOLVENT EXTRACTION OF THORIUM BY THENOYLTRIFLUOROACETONE AND THE INFLUENCE OF AQUEOUS COMPLEXATION BY THE CHELATING AGENT. Leonard Newman and Paul Klotz (Brookhaven National Lab., Upton, N. Y.). Apr. 23, 1962. Contract [AT(30-2)-Gen-16]. 15p.

Studies of the solvent extraction of thorium by benzene solutions of thenoyltrifluoroacetone led to the establishment of the existence of aqueous complexation by the chelating agent. An equilibrium constant of $1.5 \pm 0.7$ was measured for the reaction $Th^{+4} + HT = ThT^{+3} + H^+$ where the charged species are in the aqueous phase and HT represents the thenoyltrifluoroacetone in the organic phase. A value of $1.9 \pm 0.4$ was measured for the reaction $Th^{+4} + 2\ HT = ThT^{+2} + 2H^+$. A value of 22 was measured for the overall equilibrium constant for the extraction of thorium, $Th^{+4} + 4\ HT = ThT_4 + 4H^+$, where the species $ThT_4$ and HT are in the organic phase. The studies were conducted at an ionic strength of two, in a noncomplexing medium containing lithium perchlorate and in a complexing medium containing lithium chloride. The thenoyltrifluoroacetone concentration was varied from 0.1 to 0.4M and the acidity from 0.02 to 1.0M. The equilibrium constants for the aqueous phase reactions, $Th^{+4} + T^- = ThT^{+3}$ and $Th^{+4} + 2T^- = ThT^{+2}$ were calculated as $1.4 \times 10^8$ and $1.7 \times 10^{16}$ from this data and the published values of pKa and the distribution constant of the chelating agent. (auth)

**10728** (BNL-6148) STUDIES ON URANIUM RECOVERY FROM UNIRRADIATED REACTOR FUEL ELEMENTS BY VOLATILE SEPARATION IN INERT FLUIDIZED BEDS. J. J. Reilly, W. H. Regan, E. Wirsing, and L. P. Hatch (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT(30-2)-Gen-16]. 32p.

Results of studies on the recovery of U by fluoride volatilization from a number of unirradiated reactor fuels are presented. The highly exothermic reactions involved were carried out with good control through the use of inert fluidized beds. The fuels investigated were U–Zr alloy, uranium oxide, uranium carbide, and uranium metal. (auth)

**10729** (BNL-6188) ON THE SYNERGISTIC EFFECT IN SOLVENT EXTRACTION. Leonard Newman (Brookhaven National Lab., Upton, N. Y.). June 1962. Contract [AT-30-2-GEN-16]. 8p.

The studies of Irving and Edgington, and Healy on the synergistic effects of tributyl phosphate (TBP) and tri-n-octylphosphine oxide (TOPO) on the solvent extraction of thorium and other metals by thenoyltrifluoroacetone (TTA) are discussed. It is shown that the synergistic effect is a result of addition reactions as well as replacement reactions and is not a function of the metal being extracted. A compilation of equilibrium constants describing the synergistic effect of TBP and TOPO on TTA extraction is given for the following metal ions: $Th^{4+}$, $UO_2^{2+}$, $Am^{3+}$, $Cm^{3+}$, $Pm^{3+}$, $Tm^{3+}$, and $Ca^{2+}$. (D.L.C.)

**10730** (BNL-6195) THE APPLICATION OF INERT FLUIDIZED BEDS TO THE VOLATILITY REPROCESSING OF REACTOR FUELS. W. H. Regan, J. J. Reilly, E. Wirsing, and L. P. Hatch (Brookhaven National Lab., Upton, N. Y.). [1961]. Contract [AT-30-2-GEN-16]. 20p.

In the reprocessing of spent solid fuels from nuclear reactors by direct volatilization, one of the major problems is the removal of heat from the highly exothermic gas-solid reactions. The use of fluidized beds of inert granular material as heat transfer media to control these exothermic reactions forms the basis of one approach to volatile reprocessing which is under development at BNL. The engineering scale work carried out under this development program is discussed. (auth)

**10731** (HW-SA-2620) SOLVENT EXTRACTION OF CESIUM BY DIPICRYLAMINE. L. A. Bray, E. C. Martin, and R. L. Moore (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 8, 1962. Contract AT(45-1)-1350. 8p.

Various possible solvents for extraction of cesium from basic process waste solutions are described, and dipicrylamine was found to be a satisfactory and selective extractant for cesium. The extracted cesium is readily stripped with dilute acid. The separation factors of cesium from rubidium, potassium, and sodium are ~6, 28, and 2500, respectively. The effects of organic diluent, dipicrylamine concentration, sodium concentration, and temperature on the extraction were studied. (D.L.C.)

**10732** (IA-779) ANION EXCHANGE OF METAL COMPLEXES. IX. THE EFFECT OF CROSSLINKING. Y. Marcus and Daliah Maydan (Israel. Atomic Energy Establishment, Rehovoth). Sept. 1962. 21p.

Distribution coefficients for Zn, In, Ir(III), and iodide tracers between NaCl solutions and 2, 4, 8, 10, 16- and 24%-crosslinked Dowex-1 quaternary ammonium anion exchange resins were obtained. The data, corrected for resin invasion and complex formation in solution, yield parameters for the various resins, independent of the chloride concentration. The dependence of these parameters on the crosslinking is much higher for the doubly charged Zn complex in the resin than for the singly charged resin species obtained with In, Ir(III), and iodide. This dependence is explained on the basis of ion pair formation in the resin, using for the effective dielectric constant quantities calculated from the water contents of the various resins. (auth)

**10733** (IS-466) CATION EXCHANGE IN ACETONE–WATER–HYDROCHLORIC ACID. James S. Fritz and Thomas A. Rettig (Ames Lab., Ames, Iowa). [May 10, 1962]. Contract [W-7405-eng-82]. 27p.

Distribution coefficients were measured for the partition of metal ions between cation exchange resin and acetone-water-hydrochloric acid solutions. The differences in distribution coefficients of metal ions are greater in acetone-water media than in aqueous media of the same hydrochloric acid concentration. Using distribution coefficient data, conditions for column separations of mixtures can be selected. Column separations of metal ion mixtures can be effected by eluting with acetone-water-hydrochloric acid solutions of different compositions. Successful separations of a number of mixtures are reported. (auth)

**10734** (IS-508) CATION EXCHANGE SEPARATION OF DIVALENT METAL IONS FROM RARE EARTHS. James S. Fritz and Barbara B. Garralda (Ames Lab., Ames, Iowa). [June 6, 1962]. Contract [W-7405-eng-82]. 10p.

The divalent metal ions of Ca, Mg, Ni, and Sr are eluted from a cation exchange column with 1.5 M $HNO_3$ and separated from trivalent rare earths, Al, and Y. Prior sequential elution of other metal ions with hydrochloric

acid in acetone-water or with dilute hydrofluoric acid does not interfere with the separation method. (auth)

**10735** (JINR-P-1075) EKSTRACTSIONNYE SVOISTVA FERMIYA I MENDELEVIYA (TBF–$HNO_3$, TBF–HCl). (Extraction of Fermium and Mendelevium (TBP–$HNO_3$ and TBP–HCl Systems)). I. Brandshtetr, Tung-seng Wang, K. A. Gavrilov, E. Gvuzd, Ya. Maly, and M. Taube (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Reactions). 1962. 17p.

The chromatographic extraction of $Md^{256}$, $Fm^{256}$, $Fm^{252}$, and $Cf^{246}$ by tri-n-butylphosphate (TBP) from aqueous $HNO_3$ and HCl solutions was investigated. Data on distribution ratios are included. The separation factors for TBP–HCl system are higher than for TBP–$HNO_3$ system. (J.R.D.)

**10736** (NAA-SR-7511) REPROCESSING STUDIES ON IRRADIATED URANIUM CARBIDE REACTOR FUEL. J. E. Bodine, J. Guon, R. J. Sullivan, and F. W. Gandolfo (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Dec. 30, 1962. Contract AT(11-1)-Gen-8. 18p.

One-hundred-gram quantities of UC, irradiated to burnups as great as 15,000 Mwd/MTU, were converted to oxide in a controlled manner by reaction with air at temperatures up to 600°C. Because of the highly exothermic reaction, the possibility of agglomeration of the product powder was present. However, this was avoided by controlling the furnace atmosphere. The oxide was reduced in $H_2$ to form $UO_2$. After one oxidation-reduction cycle, 83.6% of the oxide passed through a 200 mesh screen. In a decladding simulation experiment, the carbide fragmented to pieces $\frac{1}{8}$ in. in dia or less, with no appreciable oxidation occurring. One oxidation-reduction cycle then produced an oxide with 92.7% passing a 200 mesh screen. Fission product and Pu decontamination factors for processed material were less than $2\frac{1}{2}$. (auth)

**10737** (NBL-189) SEPARATION AND DETERMINATION OF PLUTONIUM IN PLUTONIUM–URANIUM FUEL ELEMENTS. C. E. Pietri (New Brunswick Lab., AEC, N. J.). Jan. 1963. 6p.

Plutonium is separated from uranium in plutonium–uranium oxide and plutonium–uranium carbide reactor fuel element samples by cation exchange. Initially the refractory oxides or carbides are dissolved by refluxing in concentrated nitric acid-6N hydrofluoric acid solution. After separation, plutonium is determined by potentiometric titration at constant current with potassium dichromate; uranium may be determined similarly. At least 99.9% recovery of both plutonium and uranium was obtained on synthetic samples. (auth)

**10738** (ORNL-3374) COMPARISON OF DIALKYL PHENYLPHOSPHONATES WITH TRI-n-BUTYL PHOSPHATE IN NITRATE SYSTEMS: EXTRACTION PROPERTIES, STABILITY, AND EFFECT OF DILUENT ON THE RECOVERY OF URANIUM AND THORIUM FROM SPENT FUELS. C. A. Blake, Jr., A. T. Gresky, J. M. Schmitt, and R. G. Mansfield (Oak Ridge National Lab., Tenn.). Jan. 23, 1963. Contract W-7405-eng-26. 33p.

Di-n-butyl phenylphosphonate (DBPP) and di-sec-butyl phenylphosphonate (DSBPP) were investigated as possible substitutes for tri-n-butyl phosphate (TBP), the reagent presently employed in the reprocessing of uranium and thorium nuclear reactor fuels. The phenylphosphonates form complexes with uranium and thorium that are mostly insoluble in the aliphatic solvents commonly used as diluents for TBP but that are soluble in other diluent types, for example, aromatics and $CCl_4$. Therefore, the phosphonates were diluted with aromatics and the TBP was diluted with both aliphatic and aromatic diluents. DSBPP-aromatic solutions showed advantages over TBP-aromatic solutions during batch contact with nitric acid systems in the following respects: higher uranium extractability (1.2 to 1.8 times higher); better stability to radiation and chemical degradation (1.3 times better); higher separation of uranium from thorium (U/Th, 10 times higher) and from fission products (U/gross $\beta$, about 2.4 times higher; U/gross $\gamma$, about 1.4 times higher). Plutonium extractions with DSBPP and with TBP were nearly identical. The TBP-aromatic solvent combination also showed advantages over the TBP-aliphatic solvent combination in regard to radiation stability (2.4 times better), uranium extractability (1.5 times better), plutonium(IV) extractability (twice as good), U/gross $\gamma$ separation (3.1 times higher) and U/gross $\beta$ separation (2.4 times higher). The comparison of the DSBPP–aromatic solvent combination with TBP in the usual aliphatic diluent was consequently much more favorable to DSBPP than comparison with the TBP–aromatic. DBPP-aromatic solutions extracted uranium, thorium, plutonium, and fission products better than did TBP in either diluent system. The uranium–thorium separability was between those of the two TBP systems, and the uranium-gross $\beta$-$\gamma$ separability was about the same as for the TBP-aromatic but better than the TBP-aliphatic combination. Under irradiation the DBPP-aromatic was slightly more stable than the TBP-aliphatic, but not as stable as the TBP-aromatic. Countercurrent batch testing with simulated Purex feeds verified the single-batch contact data pertaining to uranium extractions with each reagent system and also verified the differences between TBP-aliphatic and TBP-aromatic systems. The higher uranium extractability shown by DSBPP and by DBPP in comparison with TBP suggests their use to permit lower aqueous nitric acid or nitrate salting concentrations in a uranium recovery operation, for example, to effect reduction in chemical costs and/or to alleviate problems in nitric acid evaporation and recovery from high-level radioactive waste solutions. Since use of aromatic instead of aliphatic diluents with TBP improves its uranium extractability and fission product separability, such diluents can be considered where the performance of the TBP-aliphatic combination is marginal. (auth)

**10739** (ORNL-TM-27) CHEMICAL TECHNOLOGY DIVISION, CHEMICAL DEVELOPMENT SECTION C PROGRESS REPORT FOR AUGUST–SEPTEMBER 1961. (Oak Ridge National Lab., Tenn.). Dec. 1, 1961. Contract [W-7405-eng-26]. 57p.

Final Cycle Plutonium Recovery by Amine Extraction. In development of final cycle plutonium recovery by extraction with amines, batch countercurrent testing of a proposed chemical flowsheet with simulated Purex 1BP solution confirmed the phase stability of the loaded extractant, the validity of the previously-reported extraction isotherm data, the operability of the acetic acid stripping system, and overall good physical behavior in phase mixing and disengagement. Zr–$Nb^{95}$ tracer at $7 \times 10^5$ $\gamma$ counts/min ml in the feed could not be measured directly in the product; radiochemical Zr analysis indicated a decontamination factor from Zr of $5 \times 10^4$. Extraction Performance of Degraded Process Extractants: Effect of TBP on Degradation of Amsco 125-82 with Nitric Acid. Degradation of Amsco 125-82 by irradiating or by heating in the presence of $HNO_3$ was more severe when TBP was present than when it was not. Fission Product (Cs) Recovery. Sodium dinonylnaphthalenesulfonate (0.5M in hexone) selectively extracts Cs ($E_a^0 \approx 0.5$) from simulated low $HNO_3$ (formaldehyde treated) Purex 1WW waste which was complexed with tartrate and

neutralized to pH ~1.2. Dilute $HNO_3$ readily strips the Cs and Na from the solvent. Monoheptadecylphosphoric acid extracts Cs in preference to Na from acidic Cs–Na nitrate solutions. Single stage separation factors may be as high as 40. Cursory tests show that p-dodecylphenol in xylene extracts Cs ($E_a^0$ 1-3) from tartrate-complexed, formaldehyde-treated Purex 1WW at high pH with an indicated Cs–Na separation factor of ~5. Good separation is obtained from Al and Fe. Interface Mechanism for U Extraction by Amine Sulfate. Kinetic studies of the transfer of $S^{35}O_4$ from an organic phase containing di-n-decylamine sulfate to an aqueous phase containing $Na_2SO_4$ and/or $H_2SO_4$ were done in such a way as to detect the transfer of anionic U species across the interface from aqueous to organic phase. No evidence for such transfer of anionic U species was obtained. Alkaline Earth Extraction by D2EHPA and NaD2EHP. Continued work on Sr extraction from 4M sodium nitrate by di(2-ethylhexyl)phosphoric acid in benzene resulted in a series of curves at various total reagent concentrations each showing $E_{Sr}$ as a function of pH or $[H^+]$; pH and $[H^+]$ are related in simple manner in this system. (auth)

**10740** (ORNL-TM-181) CHEMICAL TECHNOLOGY DIVISION, CHEMICAL DEVELOPMENT SECTION C PROGRESS REPORT FOR JANUARY–MARCH 1962. K. B. Brown (Oak Ridge National Lab., Tenn.). July 10, 1962. Contract [W-7405-eng-26]. 91p.

Flowsheet Demonstration of Sr-Rare Earths Recovery from Hanford Purex 1WW Waste. The solvent extraction flowsheet for recovery of fission product Sr and mixed rare earths with di(2-ethylhexyl)phosphoric acid was successfully demonstrated in mini-mixer-settler hot cell tests on a sample of Purex 1WW solution. Overall Sr recovery was ~98% and overall decontamination factors were $\sim 3 \times 10^3$ from Cs, $\sim 10^4$ from Ru, $\sim 10^5$ from Zr–Nb, $> 1.5 \times 10^3$ from rare earths, and $> 2 \times 10^3$ from Fe. Solvent Extraction of Cs. Continued studies with substituted phenols showed these compounds to have considerable promise for solvent extraction recovery of Cs from tartrate-complexed Purex 1WW waste, adjusted to pH 11-13. Although favorable results were obtained with p-dodecylphenol (PDP), later tests indicated o-phenylphenol (OPP) and 4-chloro-2-phenylphenol to be superior extractants to PDP. A number of commercial sulfonates gave significant extraction ($E_a^0$ = 0.2 to 0.5 for 0.5M reagent) of Cs from tartrate-complexed simulated Purex FTW waste but none of these compounds appeared to have advantage over dinonylnaphthalene sulfonic acid (DNNSA) previously tested. Final Cycle Pu Recovery by Amine Extraction. High-acid scrubbing was compared with low-acid scrubbing (6M vs ~0.5M $HNO_3$) in continued batch countercurrent testing of the proposed chemical flowsheet with simulated Purex 1BP. Hot-cell tests with actual Purex plant 1BP solutions showed excellent physical operation, and Pu distribution consistent with the batch countercurrent tests, but gamma decontamination factors of only ~100 to 500, much lower than expected and than required for the Pu purification. Extraction of Fe(III) from Chloride Solutions with Amines. Extraction of Fe(III) from hydrochloric acid and chloride salt solutions with typical primary, secondary, tertiary, and quaternary amines was studied, preliminary to a larger program surveying extractions of many metals in these systems. The extraction power varied in the order: Aliquat 336 (quaternary amine) > Alamine 336 (tertiary amine) > Amberlite LA-1 (secondary amine) ≫ Primene JM (primary amine). Actinide-Lanthanide Separation by the Gel-Liquid Process. A tertiary amine was incorporated into styrene-divinylbenzene copolymer beads to form a gel ion exchanger. Eu was separated from Am by elution with concentrated LiCl solutions from a column of the gel. Separations by Inorganic Ion Exchangers. Am was separated from Eu by elution from zirconium phosphate with slightly acidic concentrated LiCl solutions. Adsorption coefficients of the lanthanides increased progressively with atomic number. The lanthanide and transplutonium groups overlapped. Separation factors of 2 to 3 between Am and Cm indicated by separate batch adsorption experiments were not confirmed by column elution experiments. The orders of adsorption of lanthanides by zirconium phosphate, zirconium tungstate and ammonium molybdophosphate differed considerably. Zirconium phosphate adsorbed Cs selectively from acidic and basic Purex 1WW solutions, but the capacity was no more than 0.1 meq/g of solid, compared with >1 meq/g from pure Cs salt solutions. The Relative Affinity of the Alkali Metal Ions for Di(2-ethylhexyl)phosphoric Acid. The relative extractability of the alkali metal ions by D2EHPA in benzene from an aqueous solution of all five, in which each was 1M, was Cs ≅ Rb < K < Na ≪ Li. Water Solubilization in Benzene Solutions of Di(2-ethylhexyl)phosphoric Acid. Organic solutions of sodium di(2-ethylhexyl)phosphate can extract and hold considerable quantities of water. The volume increase and the amount of water held by benzene solution of D2EHPA over 4M $NaNO_3$ was studied as a function of total reagent concentration and the fraction of the reagent in the Na form. (auth)

**10741** (ORNL-TM-313) CHEMICAL TECHNOLOGY DIVISION. UNIT OPERATIONS SECTION MONTHLY PROGRESS REPORT, JUNE 1962. M. E. Whatley, P. A. Haas, R. W. Horton, A. D. Ryon, J. C. Suddath, and C. D. Watson (Oak Ridge National Lab., Tenn.). Jan. 29, 1963. Contract [W-7405-eng-26]. 69p.

The development of foam separation as a unit operation was considered from the distributor design and gas rate standpoints. The development of a shear and leach process for power reactor fuel processing is reported in which carburized Yankee prototype fuel assemblies were sheared to determine the effect of fuel element condition on the nature of the chopped pieces. A Squarkeen No. 3 moving blade lasted for 5894 cuts while a Kleencut blade failed at 320 cuts under normal program use. A plastics and coating material testing program for the Transuranium facility is under way. The Volatility development program is studying the recycle of the salt charge for Zr fuel element dissolution and has completed the fourth recycle test. The radioactive waste processing program has completed the test R-65 which studied the movement of mercury out of the calciner during the processing of TBP-25 waste. (auth)

**10742** (ORNL-TM-447) PROCESSING OF 5.4-YR DECAYED Zr–U ALLOY FUEL IN THE VOLATILITY PILOT PLANT (RUNS R-5 AND R-6). E. C. Moncrief (Oak Ridge National Lab., Tenn.). Dec. 29, 1962. Contract W-7405-eng-26. 21p.

Dissolution of two 5.4-yr decayed Zr–U alloy fuel elements with 75-150 g/min of anhydrous HF was performed in two runs at 495 to 650°C in NaF–LiF–$ZrF_4$ salt. Separation of uranium from fission products was accomplished by fluorination at 500 to 520°C with elemental fluorine at a dual flow rate of 6 and 13 slm for 120 to 150 min. Purification of the $UF_6$ from trace fission products was accomplished by an absorption-desorption cycle on NaF at 100 and 400°C, respectively. Product $UF_6$ was collected in a cold trap. Breakthrough of $Ru^{106}$ to the $UF_6$ product occurred in run R-5, and again in R-6 along with $Sb^{125}$. The breakthrough was attributed to excessive purge gas flow and nonoptimum absorber bed operation. $Ru^{106}$ and $Sb^{125}$ d.f.'s were

$5 \times 10^4$ and $10^3$ to $10^5$, respectively, after breakthrough. Other specific decontamination factors were $10^9$ for $Cs^{137}$, $Sr^{90}$, and TRE $\beta$; $10^4$ to $10^5$ for $Zr-Nb^{95}$, and $10^5$ to $10^7$ for Gr $\beta$-$\gamma$. $Tc^{99}$, $MoF_6$, and $Np^{237}$ continued to contaminate the product. Proposed methods for product improvement are outlined. Fuel element dissolution rates were 2.5 to 2.9 kg/hr. Fluorine utilization efficiency was low (2 to 3%) in both runs. Uranium losses to the waste salt were 0.36 and 0.06%. (auth)

**10743** (ORNL-TM-457) CHEMICAL TECHNOLOGY DIVISION, UNIT OPERATIONS SECTION MONTHLY PROGRESS REPORT, JANUARY 1961. M. E. Whatley, P. A. Haas, R. W. Horton, A. D. Ryon, J. C. Suddath, and C. D. Watson (Oak Ridge National Lab., Tenn.). Jan. 25, 1963. Contract [W-7405-eng-26]. 53p.

Steam stripping of hydrated thorium nitrate in an agitated trough gave products which were easily dispersed into sols. The effluent concentration of the $H_2$ from copper oxide fixed beds gave a typical S shaped curve. The equipment is being installed to make an engineering study of the Zirflex dissolution of U–Zr alloy fuels. The titania coatings did not prevent chemical attack from warm $HNO_3$ on high boron glass raschig rings. Tubes of unfueled AGOT graphite were not disintegrated by exposure to white fuming $HNO_3$, while 3% U-graphite fuels disintegrated in less than 1 hr. Initial tests of a spiral inclined rotary drum feeder indicated that there was some backmixing of solids when the feeder was operated at a 20 or 30° angle. A material balance flowsheet for the $HNO_3$ dissolution of $UO_2$ from 1-in. long pieces of stainless steel clad $UO_2$ is presented. Calculations of configuration factors were made for radiation between adjacent and diagonal tubes in square arrays. Performance data were obtained for the control of the interface located in bottom section of a pulse column using external water purged head pots to detect the interface position. (auth)

**10744** (TID-13765) FLUORIDE VOLATILITY PROCESSING OF LOW ENRICHED FUELS. A. A. Jonke, J. Fischer, W. Mecham (Argonne National Lab., Ill.). July 1961. Contract [W-31-109-eng-38]. 7p. (UAC-5478)

A process known as the Direct Fluorination Process, using the principle of fluidization, for reprocessing low-enrichment ceramic fuels of the type to be used in most commercial power reactors was developed by Argonne National Laboratory and is discussed in detail. Since irradiated fuels contain small quantities of Pu and the only known method for preparation of $PuF_6$ is by reaction of Pu compounds with $F_2$ at high temperatures, the properties and behavior of $PuF_6$ exert an important influence on the type of fuel-processing program to be developed. (H.G.G.)

**10745** (TID-15773) COMPARATIVE EXTRACTION OF U(VI) BY NEUTRAL AND MONOACIDIC PHOSPHATES AND PHOSPHONATES. F. D. Peppard, G. W. Mason, I. Hucher, and F. A. J. A. Brandao (Argonne National Lab., Ill.). Feb. 1962. Contract W-31-109-eng-38. 21p. (UAC-6191)

Studies were made on the extraction of U(VI) by a neutral phosphate extractant, tri(2-ethylhexyl)phosphate, and by the analogous neutral phosphonate extractant, di(2-ethylhexyl)2-ethylhexyl phosphonate, in toluene diluent from an aqueous nitrate phase. The extraction is shown to be second-power dependent upon the concentration of extractant in the organic phase and second-power dependent upon the concentration of nitrate ion in the aqueous phase. An inhibiting effect is noted at nitrate concentrations in excess of 0.5F, the K falling below the theoretical curve. Under identical conditions, the phosphonate is approximately 33 times more effective in extracting U(VI) than is the phosphate. Studies were also made on the extraction of U(VI) by a mono-acidic phosphate, di(2-ethylhexyl) phosphoric acid, and by the analogous mono-acidic phosphonate, 2-ethylhexyl hydrogen 2-ethylhexyl phosphonate, in toluene diluent from an aqueous 1.00 F (HX + NaX) phase, where X = $ClO_4^-$, $Cl^-$, $NO_3^-$. The extraction is shown to be second-power dependent upon the concentration of extractant in the organic phase and inversely second-power dependent upon the concentration of hydrogen ion in the aqueous phase. (The extraction of U(VI) by a (GO)GPO(OH) extractant is reported for the first time.) Essentially no difference between the $ClO_4^-$ and $NO_3^-$ data was noted. The difference between the $ClO_4^-$ and $Cl^-$ data is consistent with the assumption of a stability constant of $0.8 \pm 0.2$ for the $UO_2Cl^+$ complex, $\mu = 1.00$, $22 \pm 1$°C. In all of these systems, the acidic phosphonate excels the acidic phosphate by a factor of $1.9 \pm 0.2$. The relative phosphonate/phosphate data of U(VI) are compared with those for Th(IV), lanthanides(III) and actinides(III). The possible difficulties encountered in the use of neutral phosphonates and phosphates as extractants in determining stability constant of $M^{+b}$ nitrate complexes are discussed. (auth)

**10746** (TID-15792) COUNTERCURRENT MUTUAL SEPARATION OF $Y^{91}$ AND $Pm^{147}$ BY SOLVENT EXTRACTION USING PULSE COLUMN. M. A. Mandil, G. W. Mason, and D. F. Peppard (Argonne National Lab., Ill.). Feb. 1962. Contract [W-31-109-eng-38]. 47p. (UAC-6155)

The use of continuous solvent extraction was proved quite satisfactory in separating $Y^{91}$ from $Pm^{147}$, using synthetic mixtures of the nuclide pair on a tracer level. The separation was conducted in a compound perforated plate pulse column using a solvent containing 10% HDEHP, di(2 ethylhexyl) phosphoric acid, in toluene. Flow rates to the extraction column were maintained around 1 ml/min of feed, 3 ml/min scrub and 12 ml/min solvent giving one volume change per hour. Pulse frequency was maintained at 50 cycles/min and pulse amplitude at 1 cm. Varying Pm:Y ratio (by activity) in the feed from 0.08 to 135, and using the above conditions, Pm in excess of 99% and Y in excess of 97% purity were obtained. The steady state condition was reached in 12 hours, or 12 volume changes. The approach to steady state was found to be the same for any one component in all runs conducted. However, this approach was much slower than that predicted by calculations reported in the literature for discrete stages. (auth)

**10747** (TID-15923) ION-EXCHANGE IN CONCENTRATED ELECTROLYTE SOLUTIONS: III. THE SYSTEM: PYRIDINE HYDROCHLORIDE–NaCl–DOWEX–50. Walter A. Platek (Massachusetts Inst. of Tech., Cambridge. Dept. of Chemistry and Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). [June 7, 1962]. Contract [AT (30-1)-905]. 17p.

The ion-exchange behavior of trace sodium in pyridine hydrochloride was studied by measuring the variation of selectivity, $K^{Na}_{PyH}$, as a function of the external PyHCl molality and in molten PyHCl using Dowex-50 in the PyH form. The system was studied over a molality range of 0.1 to 13.1 and also over the temperature range of 25 to 156°C so that exchanges in concentrated aqueous solutions can be compared with exchanges in the anhydrous molten salt without any lengthy temperature extrapolations. (auth)

**10748** (TID-17726) STRUCTURAL ASPECTS OF ORGANOPHOSPHORUS EXTRACTANTS AND THEIR METALLIC COMPLEXES AS DEDUCED FROM SPECTRAL

AND MOLECULAR WEIGHT STUDIES. J. R. Ferraro and D. F. Peppard (Argonne National Lab., Ill.). Sept. 1962. Contract [W-31-109-eng-38]. 42p. (UAC-6955).

From freezing-point and isopiestic studies, it was found that the acidic organophosphorus extractants of the type $(GO)_2PO(OH)$ and $GOG'PO(OH)$, where G may be aryl, alkyl or mixed, are predominantly dimeric in non-polar diluents, such as n-hexane, cyclohexane, benzene and carbon tetrachloride. The dimers are very stable and appear to monomerize only in more polar solvents, such as acetone, chloroform or ethanol. Infrared spectra of these acids were made, and the positions of the phosphoryl absorption determined in terms of the electronegativity of the G group. It was concluded from these studies that for the acids $(GO)_2PO(OH)$ an ionic $P^+O^-$ and a strong acid is the better extractant; while for the acids $GOG'PO(OH)$ a phosphoryl group with high double bond character and a strong acid is a better extractant. For both acid types these criteria are provided whenever the G group is highly electronegative. (auth)

**10749** (TID-17746) THE SOLVENT EXTRACTION OF INORGANIC IONS WITH SURFACE-ACTIVE AGENTS. Technical Final Report. Arthur M. Wilson (Wayne State Univ., Detroit). Jan. 1963. Contract AT(11-1)-775. 38p.

More than 50 commercially available compounds that can be broadly classified as surface-active agents were experimentally screened. A set of four desirable characteristics that surfactants should have if they are to be useful in solvent extraction of inorganic ions was developed. Model compounds were chosen to demonstrate these principles. It was found that the most promising reagents fit the broad definition of ion-association type solvent extraction systems. A previously proposed sub-classification was accepted for extractions by ion-association. Studies designed to elucidate the stoichiometry of the extraction mechanisms were carried out. Data on the Pluronic L-60 extractions of zinc and cobalt from aqueous sodium thiocyanate solutions supported the broader definition of ion-association solvent extractions. It also cast doubt on the proposition that hydrogens are a necessary integral part of the extracted species. The potential of the quaternary ammonium salts as general extraction reagents was already known. Aliquat 336 was found to have the best properties of this class of compounds. The extraction reagent potential of the polypropylene glycols was not previously studied. When their low volatility, chemical stability, and high solubility in many organic diluents were considered, it was concluded that they could replace many separation schemes presently based on low molecular weight ethers, tributyl phosphate, and methyl isobutyl ketone. The mechanism of extractions with aryl sulfonates was previously elucidated. Their potential is not very great because of the great self-association of these molecules. No additional useful models for the weak liquid cation exchange classification were found by experiments with alkyl and aryl aminocarboxylic acids. (auth)

**10750** (UCRL-10063) THE EXTRACTION OF ACIDS BY BASIC ORGANIC SOLVENTS. I. TRIBUTYL PHOSPHATE–$HClO_4$ AND TRIBUTYL PHOSPHATE–$HReO_4$. David C. Whitney and Richard M. Diamond (California. Univ., Berkeley. Lawrence Radiation Lab.). Apr. 1962. Contract W-7405-eng-48. 33p.

The extraction of $HClO_4$ into dilute solutions of tributyl phosphate (TBP) in $CCl_4$ was studied, and the extracting species and extraction mechanism were determined. It was found that so long as the TBP concentration is <0.1 M and the stoichiometric ratio $TBP/H^+$ is >3 the only extracting species are the molecular adduct $TBP \cdot H_2O$ and the solvated hydronium ion $3TBP \cdot H_3O^+ \cdot xH_2O \ldots ClO_4^-$, an ion pair, where $0 \leq x \leq 1$. For $1 < TBP/H^+ < 3$ there are several possible species, whereas at $TBP/H^+ = 1$ the only species present in the organic phase is the salt $TBPH^+ \ldots ClO_4^-$. These results are interpreted in terms of a proposed general model for such strong acid-basic solvent extraction systems. (auth)

**10751** (UCRL-10505) THE EFFECTS OF ION HYDRATION IN SOLVENT EXTRACTION AND ION EXCHANGE (thesis). David C. Whitney (California. Univ., Berkeley. Lawrence Radiation Lab.). Oct. 12, 1962. Contract W-7405-eng-48. 192p.

The extraction of $HClO_4$, $HReO_4$, HBr, $HNO_3$, $HAuCl_4$, and $HAuBr_4$ into dilute solutions of tributyl phosphate (TBP) in inert diluents was studied, and the extracting species and extraction mechanism were determined. It was found for all the acids except $HNO_3$ that so long as the TBP concentration is ≤0.1M and the stoichiometric ratio $TBP/H^+$ is ≥3 the only extracting species are the molecular adduct $TBP \cdot H_2O$ and the solvated hydronium ion $3TBP \cdot H_3O^+ \cdot mH_2O \ldots X^-$, an ion pair, where $0 \leq m \leq 1$. For $1 < TBP/H^+ < 3$ there are several possible species, whereas at $TBP/H^+ = 1$ the only species present in the organic phase is the salt $TBPH^+ \ldots X^-$. $HNO_3$ was found to extract as an anhydrous molecular adduct at all TBP and $HNO_3$ concentrations such that $TBP/HNO_3$ is > 1; the $HNO_3$ that was extracted in excess of 1:1 with TBP was partially hydrated. These results were interpreted in terms of a proposed general model for such strong-acid-basic-solvent extraction systems. Anion-exchange studies on the salts of the fatty acids were carried out by using a quarternary ammonium (strong-base) resin. The selectivity of these resins in contact with very dilute external solutions (negligible resin invasion by nonexchange electrolyte) was considered due in large part to changes in the solvation of the ions, resulting from differences in the properties of the resin-phase solution and the external dilute aqueous solution. The resin-phase solution was a concentrated electrolyte solution with three significant differences from a dilute electrolyte solution: the cationic species was fixed on the resin matrix; electrostatic forces were stronger; and the water molecules in the resin phase had less cooperative structure. The tendency of large univalent ions to be forced out of the dilute solution into the resin phase because of their small degree of hydration and considerable water-structure-breaking character was considered, as well as the effects of specific group hydration. The elution of tracer alkali metal and trivalent cations from cation-exchange resin columns by several univalent salts and acids was investigated. The elution order in dilute solution is explained as resulting from the water-water, ion-water, and ion-resin interactions in the system. Changes in this order and deviations of the elution behavior from the simple mass-action laws, as the salt or acid concentration was increased, were interpreted as being due to changes in these interactions. On the basis of the elution behavior in concentrated solutions, a model for the prediction of resin selectivities was proposed. (auth)

**10752** (GAT-Z-5035) SEPARATION OF URANIUM FROM TRIVALENT IRON BY ION EXCHANGE. Robert Klement. Translated by R. P. Ratay (Goodyear Atomic Corp., Piketon, Ohio) from Z. Anal. Chem., 145: 9-12(1955). 6p.

A procedure is given for the separation of U and Cu from Fe(III) by exchange chromatography in 0.8N HCl solution. (J.R.D.)

**10753** SEPARATION OF CERTAIN METAL IONS FROM MIXTURES BY ELECTROCHROMATOGRAPHY. Joseph Sherma, G. Harlowe Evans, Harlan D. Frame, Jr., and Harold H. Strain (Argonne National Lab., Ill.). Anal. Chem., 35: 224-7(Feb. 1963). (TID-17488; UAC-6898)

The ions of one or a few metals were separated from multicomponent mixtures by one-way electrochromatography. The separation of particular ions is based upon differential electrical migration in stabilized solutions of specially selected background electrolytes. These methods, which have several advantages over chemical methods of segregation, permitted the isolation and identification of one or a few components without preliminary or partial resolution of the mixtures. The ions separated from complex mixtures are: Al and Pt(IV); Sb(III), Sn(IV), and Tl; As(III); As(III) + Zn, and Tl; Ba; Cr(III); Cu(II); Mn(II) and Ag; Hg(II) and Pt(IV); Ni and Ag + Au(III); Pt(IV), Tl, and U(VI); Ag and Tl; V(V) and Tl. (auth)

**10754** TRI-n-BUTYLPHOSPHINE SULFIDE AS AN ORGANIC EXTRACTANT. Robert B. Hitchcock (Univ. of Tennessee, Knoxville), John A. Dean, and Thomas H. Handley. Anal. Chem., 35: 254-5(Feb. 1963).

The extraction of 24 elements by tri-n-butylphosphine sulfide was investigated. Only two metal ions among those tested extracted well, Ag(I) (D = 625) and Hg(II) (D = 282). Elements that were partially extracted are border region acceptors and included Bi (D = 0.56), Cu(II) (D = 0.026 from 0.1 M HCl), Pb (D = 0.27), and Zn (D = 0.27). It proved difficult to strip Hg(II) from the organic phase with common reagents such as nitric acid, aqua regia, or sodium peroxide. (P.C.H.)

**10755** APPLICABILITY OF DIBUTYL ETHER FOR THE PREPARATION OF IRRADIATED NUCLEAR FUEL MATERIALS BY MEANS OF EXTRACTION. H.-J. Born, S. Krawczynski, W. Ochsenfeld, and H. Scholz (Technische Hochschule, Munich and Kernreaktor Bau- und Betriebsgesellschaft mbH, Karlsruhe, Ger.). Chem.-Ing.-Tech., 34: 537-41(Aug. 1962). (KFK-116). (In German)

The preparation of irradiated nuclear fuel materials with dibutyl ether as the extraction means has, in comparison with the Purex Process (extraction with tributyl phosphate), several advantages: higher decontamination factors, lower tendency for emulsion formation and therefore simpler handling in the extraction column and mixer-settler, smaller volumes in the washing phase for the rewashing of the uranium-containing products out of the solvent phase, and extensive relinquishing to a purification of the solvent phase (washing with diluted nitric acid is sufficient). As a disadvantage is the use of calcium nitrate as salting out agent since this is scarcely recoverable and therefore the solid content of the radioactive waste is raised significantly. (tr-auth)

**10756** EFFECTS OF THE EXTRACTION MEDIUM ON THE RECOVERY OF URANYL SULFATE BY MEANS OF TRI-n-OCTYLAMINE. Miroslav Mrnka and Zdenek Malek. Chem. Prumysl, No. 6, 297-300(1962).

Parameters controlling the extraction of uranyl sulfate from a sulfate medium by means of tri-n-octylamine (TOA) were determined. The effect of TOA-concentration with respect to organic solvent medium, benzene, chloroform, and carbon tetrachloride on extraction performance was determined. The concentration of $H_2SO_4$ in the aqueous phase was kept constant. As a result, extraction isotherms were S-shaped. The extraction coefficient increased with increased $H_2SO_4$, to reach a maximum at 0.05 M. Higher concentrations reduced the extraction. It is postulated that the uranyl sulfate–TOA-complex is displaced from the organic phase by increased $H_2SO_4$ concentrations. The extraction coefficient decreased with increased sulfate ion concentration. Correlation between the dielectric constant of the solvent and the extraction coefficient was established. Solvents with high dielectric constant reduced the extraction coefficient. However, the chemical nature of the solvent proved to be important. Chloroform, for instance, produced adducts with TOA, probably by hydrogen bonding with the mobile H of $CHCl_3$ and, consequently, extraction of uranyl sulfate was far below 100%. It is suggested that solvents that are completely inert to amines, but have a low dielectric constant, such as benzene or carbon tetrachloride, be used. (P.C.H.)

**10757** EXTRACTION OF CESIUM TETRAPHENYL BORATE FROM AQUEOUS SOLUTIONS WITH NITROBENZENE. J. Krtil, M. Fojtík, and M. Kyrš (Inst. for Physics, Czechoslovak Academy of Sciences, Řež). Collection Czech. Chem. Commun., 27: 2069-78(Sept. 1962). (In German)

The extraction of cesium tetraphenyl borate with nitrobenzene was investigated in dependence on the concentration of sodium, ammonium, iron(III), aluminum, and uranyl salts, equilibrium pH of the aqueous phase, and reagent mass in the system. The extraction was used for the separation of $Cs^{137}$ from several long-lived fission products. A semi-quantitative theory of some observed dependencies was proposed and confirmed, and approximate values of the corresponding constants were calculated. (tr-auth)

**10758** PLUTONIUM(IV) EXTRACTION WITH ALIPHATIC KETONES FROM NITRATE MEDIUM. L. Kuca (Inst. for Nuclear Research, Czechoslovak Academy of Sciences, Rez). Collection Czech. Chem. Commun., 27: 2372-9(Oct. 1962). (In German)

The relation between the extraction efficiency of aliphatic ketones for Pu(IV) and its structure in the extraction from nitric acid solutions was followed. The mechanism of Pu(IV) extraction with methyl isobutyl ketone was thoroughly investigated. (tr-auth)

**10759** THE MECHANISM OF THE EXTRACTION OF SOME CESIUM COMPOUNDS FROM AQUEOUS PHASE WITH NITROBENZENE. M. Kyrš (Inst. for Nuclear Research, Czechoslovak Academy of Sciences, Rez). Collection Czech. Chem. Commun., 27: 2380-90(Oct. 1962). (In German)

The extraction of cesium dipicrylaminate from aqueous phases by binary mixtures of nitrobenzene with another solvent was investigated. It was established that nitrobenzene is the best solvent for the extraction of several Cs compounds. These data were explained qualitatively by the solvation properties of the nitrobenzene with respect to the cesium ions. The solubility of the sodium and cesium dipicrylaminates in some organic solvents was determined, and the distribution of the cesium and rubidium dipicrylaminate between water and nitrobenzene was followed. (tr-auth)

**10760** THE RECIPROCAL EFFECT OF THORIUM AND CERIUM (IV) NITRATES ON CO-EXTRACTION WITH TRIBUTYLPHOSPHATE (TBP). A. V. Nikolaev and Yu. A. Afanas'ev (Inst. of Inorganic Chemistry, Siberian Section of the Academy of Sciences, USSR). Doklady Akad. Nauk SSSR, 147: 1380-1(Dec. 21, 1962). (In Russian)

The extraction of thorium and cerium (IV) nitrates by TBP was investigated in the presence of 1.5N nitric acid in the equilibrium aqueous phase. The presence of a small amount of cerium in the aqueous phase resulted in a sharp drop in the distribution coefficient of thorium ($K_T$). This effect was more pronounced at low concentrations of thorium. Cerium replaces thorium in the organic phase. At a

concentration of about 18 g/l of cerium, thorium is a weak salting agent, but at a concentration of cerium greater than 40 g/l, thorium has hardly any effect on the extraction of cerium. These data are valid not only for 100% TBP, but also for 20 and 60 vol % TBP in $CCl_4$. The addition of hydrogen peroxide to reduce Ce (IV) to Ce (III) improved the extraction of thorium from monazite sands. (TTT)

**10761** EQUIPMENT DECONTAMINATION IN THE MARCOULE PLUTONIUM PRODUCTION CENTER. J. Rodier, H. Bouzigues, and P. Boutot (Commissariat à l'Energie Atomique, (Paris)). Energie Nucl., 4: 352-61(Sept.-Oct. 1962). (In French)

Equipment decontamination in a nuclear center is an indispensable operation because of the cost and difficulties of replacement. It also helps to decrease the expensive stocking of radioactive materials. Surface decontamination uses both chemical and physical methods. The chemical methods are used at Marcoule. The installations and procedures used are described. Because the work is done in humid atmosphere, the risks of atmospheric contamination are greatly reduced. The operating costs do not exceed 18% of the commercial value of the articles treated. (tr-auth)

**10762** STUDIES ON THE CARRIER-FREE SEPARATION OF PRASEODYMIUM-144 FROM CESIUM OXIDE. Hua-sheng Cheng. Ho Tzu K'o Hsueh, 3: No. 3, 35-41 (July 1961). (In Chinese)

Four methods for separating carrier-free $Pr^{144}$ from $Ce^{144}-Pr^{144}$ are described. The separations were carried out by converting the rare earth activities to oxides in the presence of Ce as a carrier. Then $Pr^{144}$ was separated as carrier-free by HCl in various concentrations. The results showed that the cerium oxide mixed with asbestos and loaded in the column was capable of supplying satisfactorily pure $Pr^{144}$. (OID)

**10763** THEORETICAL INVESTIGATION OF AGITATED ION EXCHANGE BEDS. J. M. Marchello and M. W. Davis, Jr. (E. I. du Pont de Nemours and Co., Inc., Aiken, S. C.). Ind. Eng. Chem., Fundamentals, 2: 27-31(Feb. 1963).

A method was developed that permits prediction of the loss curves for agitated ion exchange beds from small-scale laboratory experiments. The principle of an overall mass transfer coefficient was used successfully in the analysis of single- and multiple-stage data. Basic relationships for the general case were developed and applied to data for the absorption of dilute complex thorium nitrate anions from concentrated $HNO_3$ with Dowex 1-X4 resin. (auth)

**10764** SOLVENT EXTRACTION OF RARE EARTHS. I. N. Plaksin, K. F. Barysheva, and A. V. Astaf'eva. Izv. Akad. Nauk SSSR, Otd. Tekhn. Nauk, Met. i Toplivo, No. 6, 185-91(Nov.-Dec. 1962). (In Russian)

Descriptions are given of rare earth separation by acid leaching and solvent extraction with TBP. Hydrometallurgical treatment of enriched rare earth products enables 85 to 95% extraction into nitric acid with 50% $HNO_3$ leaching at 80 to 90°C. Multistaged and counter-current extraction with TBP separates Ca and Fe from rare earth products, extracting up to 94 to 98% $TR_2O_3$. (R.V.J.)

**10765** THE EXTRACTION OF URANIUM AND PLUTONIUM CHLORIDES FROM FUSED SALT MEDIA. Mieczyslaw Mielcarski and Mieczyslaw Taube. Nukleonika, 7: 595-7(1962). (In English)

The properties of U and Pu fused chlorides were investigated by liquid salt–liquid organic extraction. The salt phase contained an eutectic mixture of KCl–CuCl at the molar ratio 1 : 2, and one other chloride, $Cs_2UCl_6$, $Cs_2PuCl_6$, or $PuCl_3$. The organic phase contained diphenyl (DFN) as a diluent, and an extractant, tri-n-octylamine (TOA), tri-n-butyl phosphate (TBP), or di-n-butyl phosphoric acid (HDBP). From the results, it was concluded that the extraction of Pu (added as $Cs_2PUCl_6$) from the salt phase into the organic phase is small. For U introduced into the salt phase as $Cs_2UCl_6$, the distribution ratios obtained were higher by one order of magnitude than those obtained for Pu. (P.C.H.)

**10766** SOLVENT EXTRACTION OF CATIONS WITH ALKYL PHOSPHORIC ACIDS FROM SULFATE SOLUTIONS. II. THE EXTRACTION OF $U^{VI}$ AND $Fe^{III}$ WITH BIS-(2-ETHYLHEXYL)-PHOSPHORIC ACID IN THE PRESENCE OF DIFFERENT CATIONS. T. S. Urbański and S. Minc. Nukleonika, 7: 703-13(1962). (In Russian)

Investigations on the U(VI) and Fe(III) extraction with alkyl phosphoric acids were carried out. The influence of different cations at various concentrations on the partition of U(VI) and Fe(III) with bis-(2-ethylhexyl) phosphoric acid (D2EHPA), at constant sulfate concentration and variable acidity from sulfate solutions, was studied. The dependency of the logarithm of the U extraction coefficients ($E_w^0$) on pH of the aqueous solutions in equilibrium in the presence of different cations were similar except for $Zn^{2+}$. In all the pH regions investigated the values of $E_w^0$ of U increased in the following series: Cs, Rb < K < Na < Li < Mg. The dependence of the logarithm of the ferric iron extraction coefficients on the equilibrium pH, measured in wide pH region, may be expressed by the same curve. The curve begins to branch above pH 2. The highest deviations (positive) were observed in the presence of Zn (already at a pH of about 1) and Mg (at a pH of above 1.5). On the basis of the slope (close to 1) of the common part of the curve, and from the fact that the sulfates could be detected in the organic phase it is supposed that mainly the $FeSO_4^+$ ion is extracted. (P.C.H.)

**10767** THE EXTRACTION OF MINERAL ACIDS AND URANIUM SALTS BY ALIPHATIC SULPHOXIDES. PART I. ABOUT CERTAIN PHENOMENA ACCOMPANYING THE EXTRACTION OF MINERAL ACIDS FROM AQUEOUS SOLUTIONS. Wincenty Korpak (Inst. of Nuclear Research, Polish Academy of Sciences, Warsaw). Nukleonika, 7: 715-23(1962). (In English)

Theoretical problems concerning the partition of mineral acids and uranyl salts between water and organic extractants are discussed. It is predicted that alkyl sulfoxides ought to be analogous to the alkyl phosphates and phosphine oxides in their extractive power. (auth)

**10768** RADIOMETRIC STUDIES ON THE EXTRACTION OF METAL IONS. II. EXTRACTION OF $Mn^{2+}$, $Fe^{3+}$, $Co^{2+}$, $Cu^{2+}$, AND $Zn^{2+}$ IONS BY 8-MERCAPTOQUINOLINE. Jan Mikulski and Ignacy Stronski (Inst. of Nuclear Physics, Polish Academy of Sciences, Krakow). Nukleonika, 7: 769-73 (1962). (In English)

The radioisotopes $Mn^{54}$, $Fe^{55}$, $Fe^{59}$, $Co^{60}$, $Cu^{64}$, $Zn^{65}$, $Sr^{90}$, $Y^{90}$, $Hf^{181}$, and $Th^{234}$ were used in studies on the extraction with chloroform of thiooxinates of the respective metals. The partition coefficients of $Mn^{2+}$, $Fe^{2+}$, $Co^{2+}$, $Cu^{2+}$, and $Zn^{2+}$ between water and chloroform were determined at various concentrations of hydrogen ions. (auth)

**10769** RECOVERY OF URANIUM IN CARBONATE SOLUTIONS WITH ANION EXCHANGE RESINS. Edmundo Guillermo Macchiaverna. Rev. Fac. Cien. Quim., Univ. Nacl. La Plata, 33: 81-93(1961). (In Spanish)

An ion exchange process for the recovery, purification, and concentration of the uranium contained in solutions

with excess sodium carbonate, as is the case of the alkaline leaching of uranium ores, was studied. The studies were made on batch and column procedures. The results showed that of the resins studied Amberlite IRA 400 was the most convenient. Batch tests showed that the uranium exchange is a function of the uranium concentration and that the best recovery is made with the lowest possible concentration of the leaching agent, with sulfate concentrations below 40 g/l and nitrate and chloride concentrations below 2 g/l, and with pH between 11.5 and 12. Column tests confirm the previous conclusions. At the pH maximum V and Mo are poorly fixed. Five volumes of deionized water provide an efficient washing. A solution of 1.4M $(NH_4)_2CO_3$ and of 0.9M $NaHCO_3$ is used as eluant. A counter current washing is efficient. The optimum retention times are 4 to 6 min for the sorption and washing steps and 10 min for elution. For liquids with 5% carbonate, the resin has a capacity of 55 g U/l of humid and precipitated resin milk. 99% of the U processed is recovered in the elution with a purity higher than 98%. (tr-auth)

**10770** TEMPERATURE DEPENDENCE OF DISTRIBUTION COEFFICIENTS IN URANYL NITRATE EXTRACTION FROM AQUEOUS SOLUTIONS. R. T. Golovatenko and O. Ya. Samoilov (Kurnakov Inst. of General and Inorganic Chemistry, Academy of Sciences, USSR). Zh. Strukt. Khim., 3: 529-35(Sept.-Oct. 1962). (In Russian)

Measurements were made of distribution coefficients in uranyl nitrate extraction from aqueous solutions by tributyl phosphate in benzene at 10, 15, 25, 35, 45, and 55°C. Various concentrations of Ba, Ca, Cd, Cr, Cs, K, Li, Mg, Na, Ni, Pb, Sr, and Zn nitrates were used as salting-out agents. In a manner similar to the extraction process with diethyl ester, the efficiency of the salting-out agents increases with increased charge and reduced cation radius. The $(d\ln\alpha)/(d1/RT)$ value was determined for various salting-out agents. It was found that simultaneously with dehydration the salting-out cations produce a hydrating effect on $UO_2^{2+}$. The hydrating effect is related to the disintegration of the salting-out agent. (R.V.J.)

**10771** ION EXCHANGE SEPARATION OF ACTINIDES WITH NITRIC ACID-METHANOL AND WITH EDTA. John Hines, Morris Wahlgren, and Francis Lawless (Argonne National Lab., Ill.). Oct. 1962. Contract [W-31-109-eng-38]. 26p. (UAC-6934). (TID-17625). (ORINS).

To be published in TID-7655, Proceedings of the 6th Symposium on Analytical Chemistry in Nuclear Reactor Technology, Gatlinburg, Tenn., Oct. 9-11, 1962.

Two ion-exchange systems were applied to the separation of transuranium elements. The separations were performed using tracer amounts of the respective actinides, and measurement was made by alpha counting. One system utilizes elution from anion exchange resin with methanol–$HNO_3$ solutions. Distribution coefficients were determined as functions of methanol concentration and of $HNO_3$ molarity. The effect of column operating parameters were studied to establish optimum conditions for specific separations. The largest separation factor obtained (3.25) was for the separation of Am and Cm. The elution behavior of small amounts of transuranium elements was also studied in the classical EDTA rare earth cation exchange system. Separation of the elements Am, Cm, Bk, and Cf was obtained, each being eluted at the overlap region of their respective rare earth homolog and the heavier adjacent rare earth. The techniques are also being considered for the separation of macro amounts of transuranium elements since neither requires high concentrations of acid or light element salts, and in the EDTA case dilution of the actinide elements on the column is attained by the presence of inactive rare earths. (auth)

# ENGINEERING AND EQUIPMENT

## General and Miscellaneous

**10772** (ANL-6652) HELIUM-PURIFICATION UNIT FOR HIGH-PURITY INERT-ATMOSPHERE BOXES. M. S. Foster, C. E. Johnson, and C. E. Crouthamel (Argonne National Lab., Ill.). Dec. 1962. Contract W-31-109-eng-38. 17p.

A device for purifying and recycling the helium atmosphere of two dry boxes having a combined volume of 60 $ft^3$ is described. Trace impurities are removed by passing the helium through a palladium-catalyst container and a molecular sieve bed and cooling to −195°C before passing through an activated charcoal bed. Flow rates of 10 scfm and purity levels are estimated. Regeneration procedures are given. Construction prints and a schematic diagram of the helium-purification unit are shown. (H.G.G.)

**10773** (ASD-TDR-62-428) P-N JUNCTION FORMATION BY ION BOMBARDMENT. R. R. Ferber (Westinghouse Electric Corp., Pittsburgh). Apr. 14, 1962. Contract AF33(616)-7715. 116p. (AD-278150)

The feasibility of producing silicon solar cells by ion bombardment, with a goal of 15% efficiency in the conversion of solar to electrical energy, was investigated. The effects of ion energy and bombardment at various temperatures were studied for hydrogen, nitrogen, oxygen, neon, xenon, and phosphorus. A two-million-volt Van de Graaff accelerator and a 250 kv Cockroft Walton accelerator were used to produce ions with energies ranging from 50 kev to 1 Mev. Bombardments with each of the gaseous ions have produced type conversion in p-type silicon. The n-type layers produced all have rather high resistivities (1 ohm-cm or higher) with very weak n-type conductivity characteristics. These junctions were produced by radiation damage-induced donor sites and might more appropriately be called p-i junctions. Only the phosphorus ion bombardments show evidence of impurity or chemical doping effects. The radiation damage is so great, however, that it dominates the cells' characteristics and the best solar conversion efficiencies observed have been in the order of 0.01%. (auth)

**10774** (GDC-63-001) DEVELOPMENT OF A HIGH-TEMPERATURE, NUCLEAR-RADIATION-RESISTANT PNEUMATIC POWER SYSTEM FOR FLIGHT VEHICLES. Quarterly Report, September 25, 1962–December 24, 1962. (General Dynamics/Convair, San Diego, Calif.). Dec. 24, 1962. Contract AF33(616)-7582. 69p.

The development of components for the high-temperature (1500°F) pneumatic system is continuing. Testing of the check valve and prototype relief valve, from room temperature to 1500°F, was completed and results are included. Compressor development is continuing while fabrication of the rotary actuator and servo valve is now nearing completion. A successful weld of the Udimet 500 accumulator was obtained, using the electron beam process. Further design refinement was required in the case of the pressure regulator as a result of testing conducted during this reporting period. (auth)

**10775** (LF-5) A CASCADE IMPACTOR OPERATING AT LOW VOLUMETRIC FLOW RATES. Technical Progress Report. T. T. Mercer, M. I. Tillery, and C. W. Ballew (Lovelace Foundation for Medical Education and Research, Albuquerque, N. Mex.). Dec. 1962. Contract AT(29-2)-1013. 24p.

A five-stage cascade impactor, designed to operate at 50 to 150 $cm^3$/min, is described. The device comprises four impactor stages, in which round jets are used, and a filter stage. The method of calibration of the instrument is described and it is shown that the curves of impaction efficiency as a function of the $\sqrt{\Psi}$ are similar to those of large impactors of similar design, with $\sqrt{\Psi} = 0.29$ for a collection efficiency = 0.5. For deposit thicknesses of 0.05 to 55.7 $mg/cm^2$, the wall losses vary between 1.4 and 9.8 per cent. The significance of the collection efficiency and wall losses with respect to sampling for mass distributions is discussed. (auth)

**10776** (NP-12454) PRELIMINARY DEVELOPMENT AND TESTS OF A BLAST-CLOSURE VALVE. Technical Note N-460. R. A. Breckenridge (Naval Civil Engineering Lab., Port Hueneme, Calif.). Sept. 1962. 23p.

The ventilation systems of shelters providing blast protection must have automatic valves to prevent ingress of damaging pressure waves through the air ducts. A 600-cfm blast-actuated closure valve is described which is being developed at the U. S. Naval Civil Engineering Laboratory for overpressure up to 100 psi. A series of air-flow and blast tests were performed which show that the valve has the potential to satisfy all of the desirable criteria but requires further development. (auth)

**10777** (NP-12474) FEASIBILITY STUDY TOWARD DEVELOPMENT OF RADIATION RESISTANT SOLAR CELL. Monthly Report, December 1–December 31, 1962. M. D. Cheslow (Electro-Optical Systems, Inc., Pasadena, Calif.). Jan. 15, 1963. Contract NAS7-92. 16p. (EOS-2080-ML-14).

Calculations were made which indicate that the graded-base solar cell is more radiation-resistant than a uniform base cell by a factor of 5 to 15 in space sunlight for 1-Mev electrons. The fabrication of uniform base cells is reported. (D.L.C.)

**10778** (NYO-9742) HIGH PRESSURE PUMP SEAL DEVELOPMENT. Engineering Quarterly Progress Report, December, January, February 1961-62. Paul J. Zanoni (Worthington Corp. Advanced Products Div., Newark, N. J.). Mar. 5, 1962. Contract AT(30-1)-2682. 14p.

Test results indicated that graphite is not suitable for seal face material. A program to evaluate various materials and seal face geometries was initiated. A seal run using nucerite-bearium combination was carried on for six hours. (J.R.D.)

**10779** (NYO-9743) HIGH PRESSURE PUMP SEAL DEVELOPMENT. Engineering Quarterly Progress Report, March–May 1962. Paul J. Zanoni (Worthington Corp. Advanced Products Div., Newark, N. J.). June 11, 1962. Contract AT(30-1)-2682. 30p.

Results of tests indicate that the nucerite-bearium seal system is compatible. This combination was operated as long as 9 hours without serious damage. In other work, the test rig was modified to eliminate pressure fluctuations and extraneous dirt, and Type IIA seal parts were designed. (J.R.D.)

**10780** (NYO-9859) STRUCTURAL INTEGRITY OF SHIPPING CONTAINERS FOR RADIOACTIVE MATERIALS. PART I. STUDY OF TRANSPORT OPERATIONS AND CONTAINER CONSTRUCTION. H. G. Clarke, Jr., and M. M. Reddi (Franklin Inst. Labs. for Research and Development, Philadelphia). July 1962. Contract AT(30-1)-2539. 145p.

A program was undertaken to develop quantitative methods for assessing the structural integrity of shipping containers for radioactive materials during both transport operations and accidents. The forces encountered during normal travel and accidents are analyzed, and the problem of proper rigging (tie-down) is discussed. The construction of existing shipping containers is considered, and the use of fins for increasing the impact resistance is suggested. An experimental program using small-scale models to study the response of containers to impact is outlined. (D.L.C.)

**10781** (TID-17311) THE APPLICATION OF GAS-LUBRICATED BEARINGS TO HIGH SPEED TURBOMACHINERY. Quarterly Technical Report, June 1–August 31, 1962. E. J. Gunter, J. G. Hinkle, and D. D. Fuller (Franklin Inst. Labs. for Research and Development, Philadelphia). Contract AT(30-1)-2512. 97p. (Q-A2392-3-6)

Procedures are being developed for designing practical gas-lubricated bearings for use in high-speed, turbomachinery. Effort was applied to the design and analysis of two separate bearing systems; one system requiring external pressurization, and the other of a self-acting nature. Because of stability problems frequently encountered in 360° journal bearings, particularly if gas-lubricated, attention was directed toward the development of pivoted-pad, self-acting bearings. This bearing arrangement is inherently more stable than the conventional full journal bearing; and in addition has the capacity to be self aligning. A review of the theoretical and experimental work that was performed on both the self acting (SA-2) and the externally pressurized (EP-2) rotors is presented. The EP-2 rotor was dynamically balanced and run. Failure was encountered at 15,000 rpm. The rotor was studied in an effort to determine possible reasons for failure. The SA-2 rotor was tested at speeds up to 18,000 rpm. The load-deflection characteristics of the hydrostatic lifters were determined. Film thickness measurements of the self-acting pivoted shoes were taken. A preliminary design of a self-acting thrust bearing was tested up to speeds of 5,000 rpm. Correlation of film thickness measurements and theory is presented. (auth)

**10782** (TID-17756) RECENT PROGRESS ON THE DEVELOPMENT OF GAS-LUBRICATED BEARINGS FOR HIGH SPEED ROTATING MACHINERY. E. J. Gunter, Jr., and D. D. Fuller (Franklin Inst., Philadelphia). [1963]. Contract [AT(30-1)-2512]. 43p.

Problems that may be encountered when high-speed rotors are operated on gas-lubricated bearings are reviewed. Although certain of these difficulties are peculiar to the type of bearing that is used, all gas-lubricated bearings have common characteristics of low damping and relatively low spring rates. The influence of gas-lubricated bearings on balance requirements, critical rotor speeds, and the susceptibility of the rotor system to external excitation, especially when near a critical speed, is discussed. The tilting-pad journal bearing shows much promise for high-speed rotor applications and a comparison between theoretical and experimental performance is given for load-carrying capacity and optimum pivot position. The agreement between measured and predicted values of film thickness was good. (auth)

**10783** (TID-17773) CONSTRUCTION AND EVALUATION OF A THREE DIMENSIONAL STRAIN ROSETTE. W. E. Baker and R. C. Dove (New Mexico. Univ., Albuquerque). [Dec. 1962]. For Sandia Corp., Albuquerque, N. Mex. Contract [AT(29-1)-789]. 26p. (SCDC-2968)

A strain rosette was developed which could be used to determine the state of strain at interior points in homogeneous isotropic solids. The three-dimensional rosette requires no new strain gage theory, and all circuitry, equipment, and recording techniques used with surface gages are applicable to this system. (J.R.D.)

**10784** (USNRDL-TR-601) A SYSTEM FOR RAPID HANDLING OF AN IRRADIATED SOLUTION. A. E. Greendale and D. L. Love (Naval Radiological Defense Lab., San Francisco). Nov. 13, 1962. 15p.

An apparatus was constructed for rapidly transferring irradiated solutions to a container for fast radiochemical separations. A "rabbitt" containing a solution is irradiated; within 1 second after irradiation it is transported through a pneumatic system to a receiver; there it impales itself onto two hypodermic needles connected to a container under vacuum. The irradiated solution and one acid wash of the rabbit are quantitatively transferred to the container within 2 seconds. Since the system is completely contained, there is no contamination of the laboratory area nor danger to personnel. (auth)

**10785** THE SWEDISH GAMMA RADIATION STANDARD LABORATORY. R. Thoraeus (Inst. of Radiophysics, Stockholm). Acta Radiol., 58: 445-58(Dec. 1962). (In English)

The constructional arrangements of a national standard gamma radiation laboratory embodying two $Co^{60}$ sources, two $Cs^{137}$ sources, and two radium sources are described. Radiation measurements are made by cavity chambers, one of which, used as a standard, was calibrated against four national free-air standard chambers. A special condenser dosimeter, which is used as a reference instrument that can be sent to the radiotherapy centers in Sweden, is also described. (P.C.H.)

**10786** GENERAL DESIGN OF HIGH-CAPACITY MIXER-SETTLERS. PART I. C. Hanson and D. A. Kaye (Bradford Inst. of Tech., Eng.). Chem. Process Eng., 44: 27-30(Jan. 1963).

Two possible designs of mixer-settlers (a horizontal one and a vertical one), which meet the criterion for a geometrically limited chemical processing plant capable of handling high volumetric through-puts, are discussed. Although they were developed for nuclear purposes, they should be equally applicable to other processes involving solvent extraction since one of their main attractions is low hold-up and small space requirement. (P.C.H.)

**10787** THE DEVELOPMENT OF THE MASTER-SLAVE MANIPULATOR. W. K. Curtis. Nucl. Energy, 4-16(Jan. 1963).

A great deal has been written about handling cells and remote operations in which the master-slave manipulator has been used; enough, in fact, to have stimulated considerable interest in these machines. Little has been written, however, of their construction and function. This brief review will help to put these interesting machines in their proper perspective. (auth)

## Heat Transfer and Fluid Flow

*Refer also to abstract 12012.*

**10788** (62GL132) THE INFLUENCE OF LIQUID VISCOSITY ON FLOODING IN A VERTICAL TUBE. G. B. Wallis (General Electric Co. General Engineering Lab., Schenectady, N. Y.). Aug. 1962. 25p.

The results of flooding experiments using fluids of various viscosities are reported and correlations are suggested in terms of a dimensionless viscosity parameter. The

wave motion of the gas-liquid interface is described qualitatively. The influence of viscosity on the transition from flooding to upwards co-current flow is found to be negligible. (auth)

**10789** (AE-100) MEASUREMENTS OF BURNOUT CONDITIONS FOR FLOW OF BOILING WATER IN VERTICAL ANNULI. [PART] I. Kurt M. Becker and Gunnar Hernborg (Aktiebolaget Atomenergi, Stockholm). 1962. 40p.

Measurements were made of burnout conditions for flow of boiling water in an annulus with an inner diameter of 9.92 mm, an outer diameter of 17.42 mm, and a heated length of 608 mm. Data were obtained for external heating only, internal heating only, and dual uniform and non-uniform heating. The following ranges of variables were studied and 978 burnout measurements were obtained: pressure, 8.5 to 37.5 kg/cm$^2$; inlet subcooling, 60 to 205°C; steam quality, 0.10 to 0.91; inner surface heat flux 0 to 303 W/cm$^2$; outer surface heat flux 0 to 374 W/cm$^2$; and mass velocity, 71 to 961 kg/m$^2$ sec. The results are presented in diagrams where the burnout steam qualities, $x_{BO}$, were plotted against the pressure with the surface heat fluxes as parameters. The data were correlated by curves. The scatter of the data around the curves is less than ±5 per cent. In the case of equal heat fluxes on both walls of the annulus, burnout always occurred on the inner wall, and the data compared rather well with round duct data. When the annulus was heated internally only, the data showed very low burnout values in comparison with the results for dual heating and round ducts. This disagreement was explained by considering the climbing film flow model and by the fact that only a fraction of the channel perimeter was heated. For external heating, the data are somewhat lower than corresponding round duct data, but rather high in comparison with internal heating. The climbing film flow model was also used to interpret this observation. For dual non-uniform heating, it was found that the outer surface may be overloaded from 30 to 70 per cent compared with the inner surface without reducing the margin of safety in respect of burnout for the annulus. It was further observed that when the heat flux for the wall on which burnout occurs is increased, the burnout steam quality for the channel decreases. If, however, the heat flux for the opposite wall is increased, the burnout steam quality also increases. It was also observed that the highest burnout values are obtained when burnout occurs simultaneously on both cylinders. Finally the results were compared with annuli and rod cluster data in published works, and a method for predicting burnout conditions in rod clusters is proposed. (auth)

**10790** (AERE-R-4197) ANALYSIS OF HEAT AND MASS TRANSFER BETWEEN SOLID WALL AND FLUID STREAMS AT BOTH LOW AND HIGH REYNOLDS NUMBERS. V. R. Gowariker and F. H. Garner (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). Nov. 1962. 46p.

Heat and mass transfer for fluid flow in smooth tubes are considered at a wide range of Prandtl or Schmidt numbers with Reynolds numbers from $10^3$ to $10^5$. A treatment applicable to both laminar and turbulent flows is presented. The concept of three fluid layers was abandoned and a single equation is proposed to describe the flow variations at different distances from the wall to cover the whole region of heat and mass transfer. Theoretical predictions are compared with experimental data from various sources. The agreement with the data appears to be noteworthy. (auth)

**10791** (BNL-6142) BOILING POTASSIUM HEAT TRANSFER PROJECT LOOP DESIGN AND DEVELOPMENT. J. C. Chen (Brookhaven National Lab., Upton, N. Y.). Apr. 30, 1962. Contract [AT(30-2)-Gen-16]. 18p.

A general review of the project to investigate heat transfer characteristics of alkali metals in forced convective flow is presented in which the progress since June 1961 is emphasized. Information concerning the design and development of the test loop is included. (J.R.D.)

**10792** (GEAP-4148) TWO-PHASE PRESSURE LOSSES. Quarterly Progress Report No. 3, August 12–November 12, 1962. Earl Janssen and J. A. Kervinen (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). Dec. 12, 1962. Contract AT(04-3)-189. 29p.

The pressure drop along a 0.5-in. × 1.75-in. channel in the horizontal and in the vertical, flow up and flow down, orientations were measured under single and two-phase flow conditions at 600, 1000, and 1400 psia. The flow was varied from $0.25 \times 10^6$ to $2.0 \times 10^6$ lb/hr-ft$^2$, and the quality from zero to 95 per cent. The pressure drop across four different contraction-expansion geometries was also measured under single and two-phase flow conditions. The two-phase pressure drop results for the straight channel at 1000 psia and for three of the contraction-expansion geometries under single phase flow are reported. The pressure drop curves for the straight channel in three orientations, all at the same flow, tend to converge as the quality is increased. This is due to the decreasing magnitude of the hydrostatic term with increasing quality. Larson's data were used to evaluate the hydrostatic term, and from this a frictional loss was calculated for all three orientations. Agreement between the three orientations is good as high flows, and at low flows and high qualities. It is poor at low flows and low qualities. Poor agreement means that either the friction loss is not independent of the direction of flow or that Larson's data are not applicable, or both. The horizontal pressure drop data were used to evaluate the friction loss for the vertical cases, and from this, the void fraction $\alpha$ was calculated for both flow up and flow down. $\alpha$ for flow up at the lower flow conditions ($0.5 \times 10^6$ and $1 \times 10^6$ lb/hr-ft$^2$) is in good agreement with Larson's results except at the higher qualities. At the high flow condition ($2 \times 10^6$ lb/hr-ft$^2$), $\alpha$ is in relatively good agreement with the homogeneous model. $\alpha$ for flow down at $0.5 \times 10^6$ lb/hr-ft$^2$ lies in the band $0.85 < \alpha < 0.92$ for qualities from 10 to 74 per cent. At the high flow condition, $\alpha$ appears to be in fair agreement with Larson's curve. The single phase loss coefficient for the three expansion-expansion geometries is plotted versus channel Reynolds number. High speed movies were taken of two-phase flow in both the straight channel and with one of the expansion-contraction geometries, at selected conditions of flow and quality. With the straight channel horizontal, $G = 1 \times 10^6$ lb/hr-ft$^2$, asymmetry was observed in the flow pattern at 20 per cent quality, and strong stratification at 5 per cent quality. With the contraction-expansion insert installed, flow vertical, $G = 1 \times 10^6$ lb/hr-ft$^2$, 5 per cent quality, a jet was observed in the region past the insert with strong mixing action along the jet boundaries. The two-phase mixture in and past the insert had a finely homogenized appearance. Because of difference in character of horizontal flow compared with vertical flow, particularly at low flows and qualities, the frictional pressure loss may be quite different. The need for quantitative measurement of voids in the flow up and flow down cases is clearly indicated. (auth)

**10793** (HW-72097(Rev.)) HEAT TRANSFER EXPERIMENTS FOR OUT-OF-REACTOR COOLING OF PRTR FUEL ELEMENTS BY TRANSVERSE AIR FLOW. E. D. Waters, T. W. Ambrose, and M. E. Shockley (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Dec. 1962. Contract AT(45-1)-1350. 35p.

Results of heat transfer experiments are presented in which prototype Plutonium Recycle Test Reactor (PRTR) fuel elements were cooled by the transverse flow of air. The equipment and conditions were chosen to simulate the conditions which will exist in the fuel examination cell of the PRTR. Fuel surface temperatures and heat transfer coefficients are evaluated as a function of location on the fuel, the heat flux, and the air flow rate. Pressure drop data are also presented. (auth)

**10794** (HW-73902(Rev.)) EXPERIMENTAL OBSERVATIONS OF UPSTREAM BOILING BURNOUT. E. D. Waters, J. K. Anderson, W. L. Thorne, and J. M. Batch (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Nov. 1962. Contract AT(45-1)-1350. 18p.

Boiling burnout conditions are generally postulated and observed to occur at the outlet end of uniformly heated test sections. However, during experiments with a 12-ft-long × 0.44-in.-ID test section, boiling burnout conditions were sometimes observed to begin at various locations upstream from the test section outlet. Upstream burnout was observed at mass velocities of $5 \times 10^6$ lb/hr-ft$^2$ and higher but not at lower mass velocities. In some experiments the heat flux was purposely increased beyond the initial detection of boiling burnout (film boiling), allowing the condition to spread along the test section. Similar results were obtained for both vertical and horizontal positioning with a system pressure of 1500 psig. The experiments show the necessity of installing burnout detectors along the entire length of the test section. The experiments also show the need for a hydrodynamic model of boiling burnout which would allow prediction of upstream burnout conditions. (auth)

**10795** (IDO-28595) ARMY GAS-COOLED REACTOR SYSTEMS PROGRAM. HECTIC II—AN IBM 7090 FORTRAN COMPUTER PROGRAM FOR HEAT TRANSFER ANALYSIS OF GAS OR LIQUID COOLED REACTOR PASSAGES. N. Kattchee and W. C. Reynolds (Aerojet-General Nucleonics, San Ramon, Calif.). Dec. 1962. Contract AT(10-1)-880. 79p.

HECTIC-II is an IBM 7090 FORTRAN computer program for calculating pressure drop, flow rates, heat transfer rates, and temperature in heat exchangers such as fuel elements of typical gas- or liquid-cooled nuclear reactors. The effects of turbulent momentum and heat interchange between flow passages are considered. The computation procedure amounts to a "nodal" or "lumped parameter" type of calculation. The axial mesh size is automatically selected to assure that a prescribed accuracy of results is obtained. HECTIC-II supersedes HECTIC. (auth)

**10796** (IS-571) THERMAL EFFICIENCY OF COATED ANNULAR FINS OF UNIFORM THICKNESS. William F. Brown, Ray W. Fisher, and Henry M. Black (Ames Lab., Ames, Iowa). Nov. 1962. Contract W-7405-eng-82. 23p.

A high thermal conductivity is advisable for annular fin material, yet at high temperatures the melting point, low oxidation resistance, and cost reduce the selection of available materials. If a material, such as copper, is clad or plated with another material of high oxidation resistance, the difference in heat transfer of the coated fin as opposed to the uncoated fin is shown to be controlled by the dimensionless parameter, $k_b/h\delta_b$. Using this parameter, the equation for the efficiency of coated annular fins of uniform thickness was developed. Data obtained from an IBM 704 computer are presented in the form of curves. (auth)

**10797** (KAPL-M-EC-27) THD2—TEMPERATURE DISTRIBUTION IN A SLAB WITH INTERNAL HEAT GENERATION. Harvey H. Rhodes (Knolls Atomic Power Lab., Schenectady, N. Y.). Oct. 18, 1962. Contract W-31-109-eng-52. 35p.

THD2 is a digital computer program for determining steady-state, one dimensional temperature distribution in a slab with internal heat generation. Either exponential or uniform heat generation distributions may be considered. A flexible input technique was developed to facilitate the use of the program in parameter study problems. The program running time is approximately three minutes per 1000 points. (auth)

**10798** (KAPL-M-LXW-1) HAFMAT—STEADY-STATE FLOW DISTRIBUTION PROGRAM. L. H. Wunderlich (Knolls Atomic Power Lab., Schenectady, N. Y.). Nov. 23, 1962. Contract [W-31-109-eng-52]. 54p.

The HAFMAT code was developed for the purpose of calculating the distribution of flow to all paths of any given flow system. In doing so, the system is considered as a network of flow paths or pipes. The flow geometry and heat addition must be specified for every flow path and the system boundary conditions must also be defined. Linear simultaneous equations are used to assure a flow and thermal energy balance at each junction of two or more flows, and an iterative procedure is used to adjust an initially assumed flow distribution until the correct flow distribution is obtained. (auth)

**10799** (LAMS-2809) THE RATH MESHER—A 7090 PROGRAM FOR PREPARING INPUT DATA FOR HEAT CONDUCTION CODES. Richard F. Thomas, Jr. (Los Alamos Scientific Lab., N. Mex.). Dec. 1962. Contract W-7405-eng-36. 37p.

A description is given of an IBM 7090 code which divides irregularly shaped two-dimensional figures into mesh nodes suitable for use in heat conduction calculations using any of several existing general geometry heat codes. An example of its use is included. (auth)

**10800** (NAA-SR-7954) CRITICAL HEAT FLUX OF SOME POLYPHENYL COOLANTS. J. M. Robinson and H. Lurie (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Feb. 1, 1963. Contract AT(11-1)-Gen-8. 28p.

The critical heat flux (CHF) of Santowax R (a polyphenyl mixture), Santowax R containing diphenyl and/or radiolytic high boilers, and coolant from the Organic Moderated Reactor Experiment (OMRE) was measured as a function of mass velocity, subcooling, and pressure under forced convection, subcooled boiling conditions. The data were correlated by equations of the form $q_c = A + B\Delta T_s G^{0.8}$ where $q_c$ = critical heat flux, Btu/hr-ft$^2$; $\Delta T_s$ = subcooling, °F, and G = mass velocity, lb/sec-ft$^2$. A and B are empirical constants that depend only on the coolant composition. Over the range of variables covered, the critical heat flux data were correlated by: a) Santowax R, $q_c = 198{,}000 + 14.5\Delta T_s G^{0.8}$. b) A mixture of Santowax R and 27 wt % radiolytic high boilers (HB) $q_c = 353{,}000 + 16.9\Delta T_s G^{0.8}$. c) Mixture (b) with diphenyl added to give 2.9 to 7.4 total wt % diphenyl $q_c = 282{,}000 + 23.0\Delta T_s G^{0.8}$. d) OMRE,

Core II coolant $q_c = 219{,}000 + 29.2\Delta T_s G^{0.8}$. At the same subcooling and mass velocity, the critical heat flux increases as a result of adding radiolytic high boilers to Santowax R. For $\Delta T_s G^{0.8} \geq 11{,}000$, the CHF of Santowax R + HB + diphenyl is greater than the CHF of Santowax R + HB, and that of OMRE coolant is higher than either. (auth)

**10801** (NYO-10345) THE EFFECT OF APPLIED VOLTAGE ON BOILING HEAT TRANSFER. Annual Progress Report, September 1960–February 1962. Michael Markels, Jr. and Robert L. Durfee (Atlantic Research Corp., Alexandria, Va.). June 2, 1962. Contract AF(30-1)-2404. 28p.

Boiling heat transfer to isopropanol from a steam-heated chrome-plated Cu tube 0.375 in. in dia. was increased as much as four times the normal peak heat flux by the application of up to 3,500 volts d-c between the liquid and the tube. The heat transfer coefficient at 3,500 volts and a $\Delta T$ of 128°F was 3,120 Btu/hr sq.-ft-°F. The process completely eliminated film and transitional boiling above 500 volts, and the boiling is nucleate over the entire range of temperature difference covered (40 to 180°F). This large effect of voltage appears to involve a condenser effect which destabilizes the vapor space between the liquid and the heat transfer surface and is not due to dielectrophoresis in a convergent field. The results obtained substantiate the theories of surface wetting during transitional boiling. (auth)

**10802** (TID-17664) HEAT TRANSFER IN COUETTE FLOW OF A RADIATING FLUID WITH VISCOUS DISSIPATION. R. Viskanta (Argonne National Lab., Ill.). Sept. 1962. Contract [W-31-109-eng-38]. 45p. (UAC-6983)

Consideration is given to the coupling of conduction and thermal radiation in the presence of viscous heat dissipation in Couette flow. Both the stationary and the moving walls are assumed to be diffuse, isothermal parallel surfaces a finite distance apart; the fluid between them emits and absorbs thermal radiation in a diffuse manner. The problem is formulated in terms of a nonlinear integrodifferential equation, and the solution is obtained by the method of Barbier. Numerical examples show the influence of the dimensionless parameters as well as the difference between the results for an opaque and a transparent moving wall. The effects of the temperature level, the optical thickness of the fluid, and the emissivity of the walls on the temperature distributions, local radiant energy fluxes and heat transfer characteristics are investigated. The temperature profiles obtained by the approximate Barbier's method are compared with those calculated by a more exact method of reference, and the heat transfer results predicted by the two methods are also examined. (auth)

**10803** (TID-17719) BUBBLE MOTION IN TURBULENT LIQUID STREAM. Quarterly Progress Report No. 6, September 15, 1962–December 15, 1962. B. T. Chao (Illinois. Univ., Urbana). Jan. 2, 1963. Contract AT(11-1)-1069. 18p.

The experimental work of the study of bubble motion was completed, and the data are now being processed. A sample graph of the terminal relative velocity of air bubbles in turbulent water and a sample photograph of a single air bubble are given. The fluctuations in the terminal velocity and the wall effects in the evaluation of the relative velocity are discussed. Equations are given for finding the true location and size of bubbles from optical data. The status of the research study on the spherical collapse of vapor bubbles in a subcooled liquid is outlined. (D.L.C.)

**10804** (WCAP-1607) MIXING IN FLOW PARALLEL TO ROD BUNDLES HAVING A SQUARE LATTICE. P. A. Nelson, A. A. Bishop, and L. S. Tong (Westinghouse Electric Corp. Atomic Power Dept., Pittsburgh). July 1960. 27p.

The Peclet Number ($\epsilon_m/V\ D_e$) for flow parallel to a rod bundle was experimentally determined to be 0.003 which is in good agreement with Bettis' previous result. The test section was a 56-inch long 12 × 12 rod bundle of 0.340-inch rod diameter and 0.422-inch rod pitch. Ferrules were brazed onto rods as spacers at levels of eight inches apart with a rod-flow-area to ferrule-flow-area ratio of 1.105. The equivalent length of a ferrule for the flow mixing was estimated to be 7 $D_e$. The test was conducted by injecting $LiNO_3$ into the rod lattice at the upstream of water flow and the sample was taken at various distances downstream of the flow in the test section. The mixing subfactor of $F_{\Delta H}$ for a row of hot channels located at the edge of the fuel assembly was estimated to be 0.95. This estimation was based on an assumed power peaking subfactor of 1.14, mechanical tolerance subfactor of 1.14, and a mixing effectiveness of 0.20. (auth)

**10805** (Y-1410) SALT BATH HEAT TRANSFER RATES FOR URANIUM PLATE. R. B. Burditt (Union Carbide Nuclear Co. Y-12 Plant, Oak Ridge, Tenn.). Aug. 26, 1960. Contract W-7405-eng-26. 62p.

An experimental study was made of the heat transfer conditions of a salt bath-salt linear system of the type used for annealing uranium sheet. This system utilizes a small inner bath (liner) set into a larger outer bath which is used as a heat sump. Film coefficients were derived for salt-to-uranium, salt-to-liner-to-salt, and uranium-to-air systems for thin sheet. Conditions existing for rolled sheet for 7- and 12-min annealing cycles were studied. Film coefficients were then used in combination with thermal conductivity values to obtain mathematical solutions for the process of heating and cooling plates of finite thickness and area. Results were checked experimentally for plates ranging in thickness from 0.274 to 1 in. and in surface area from $6\frac{1}{2}$ by $6\frac{1}{2}$ to $18\frac{1}{2}$ by $18\frac{1}{2}$ in. Newtonian form constants were worked out for approximating the results on thick plates. (auth)

**10806** (AEC-tr-5602) AN INVESTIGATION OF BURNOUT DURING THE FLOW OF SUBCOOLED WATER THROUGH SMALL-DIAMETER TUBES AT HIGH PRESSURES. P. I. Povarnin and S. T. Semenov. Translated from Teploenerg., 7: No. 1, 79-85(1960). 17p.

Results obtained in investigations of burnout during water flow in tubes are presented. An equation is developed for calculation of the critical heat flux ($q_{cr}$) over a wide variation of coolant water flow velocities. The equation is also useful in subcooling calculations. (J.R.D.)

**10807** (EURAEC-449) INVESTIGATION OF THE CRITICAL BOILING WATER BURNOUT. Quarterly Report No. 4, July 1 to September 30, 1962. (Maschinenfabrik Augsburg-Nürnberg A. G., Nuremberg). Work Performed under United States–Euratom Joint Research and Development Program. Contract 057-61-RDD. 10p. A translation.

The preparations for the construction of the test stand and the research program were continued. The constructional work at the test stand was brought to a close and the construction of the testing tracks for the test pieces was continued. A high-precision differential manometer was designed, as well as a testing gear for accurate measurement of the coefficient of thermal conductivity of the tubes under test. Concerning the measuring technique, experi-

ments on temperature changes were performed with the double thermocouple and an insulated lead-in for test wires was tried out at high pressures. In the theoretical field, preparations were made for the evaluation of results, and in this connection a program was established for calculating the radial temperature distribution in electrically heated tubes by means of a computer. (auth)

**10808** HIGH-FLUX HEAT TRANSFER CHARACTERISTICS OF PURE ETHYLENE GLYCOL IN AXIAL AND SWIRL FLOW. W. R. Gambill and R. D. Bundy (Oak Ridge National Lab., Tenn.). A.I.Ch.E. (Am. Inst. Chem. Engrs.) J., 9: 55-9(Jan. 1963).

Measurements were made of heat transfer rates and peak heat flux for atmospheric-pressure pool boiling, and of adiabatic and diabatic friction factors, nonboiling and local-boiling heat transfer rates, and burnout heat fluxes for both axial- and twisted-tape swirl-flow forced convection of pure ethylene glycol. Test sections were electrically heated copper, 347 stainless steel, and A-nickel tubes. Both axial- and swirl-flow friction factors are in good agreement with available generalized correlations. At the higher Reynolds numbers and heat fluxes, axial-flow nonboiling heat transfer coefficients show a dependence of Nusselt number on $N_{Re}^{0.98}$ rather than the traditional $N_{Re}^{0.80}$. Swirl-flow nonboiling heat transfer coefficients from both the glycol data and previously obtained water data are satisfactorily correlated by a single equation. Nucleate-boiling heat transfer coefficients for both ethylene glycol and water fall approximately 50% above Kutateladze's suggested average line. The atmospheric-pressure pool-boiling peak flux is 168000 Btu/hr $ft^2$. Forced-convection burnout heat fluxes are correlated in a number of ways, including a new additive method, which appears to be generally applicable to a large variety of coolants, geometries, and flow conditions. (auth)

**10809** MINIMUM POWER REQUIREMENTS FOR SLURRY TRANSPORT. Joel Weisman (Westinghouse Electric Corp., Pittsburgh). A.I.Ch.E. (Am. Inst. Chem. Engrs.) J., 9: 134-8(Jan. 1963).

An analysis was made of flocculated slurries outside of their compaction zone. The analysis of the flocculated slurries was complicated by the fact that measurements of solid particle size and density are not necessarily indicative of those of the flocs. Successful correlation of available experimental data appears to justify the supposition that the mechanism for particle suspension in conduits is similar to that in mechanical mixers. It was concluded that in order to transport a nonflocculated slurry outside its compaction zone without deposition of solids, it is necessary that the flow be turbulent. For very slowly settling particles in small lines, the only requirement is that the flow be fully turbulent. For more rapidly settling particles or larger conduits, greater eddying movements are necessary to supply the vertical forces that keep the particle in suspension. (P.C.H.)

**10810** THE TEMPERATURE FIELD IN A REACTOR CYLINDRICAL FUEL ELEMENT COOLED BY A TURBULENT LIQUID FLOW. V. S. Ermakov, N. G. Kondrashov, T. L. Perel'man, E. A. Romashko, and V. B. Ryvkin. Inzh.-Fiz. Zh., Akad. Nauk Belorussk. SSR, 5: No. 9, 38-43 (Sept. 1962). (In Russian)

A method is proposed for numerical solution of a system of equations describing stationary heat transfer between a rod with internal heat sources and a liquid flow cooling it. (auth)

**10811** HIGH TEMPERATURE HEAT TRANSFER. M. Dalle Donne and F. H. Bowditch. Nucl. Eng., 8: 20-9 (Jan. 1963).

Experimental results for laminar, transitional, and turbulent flow of air through circular tubes are given. A survey was made of literature on high-temperature heat transfer. Data were correlated in terms of dimensionless numbers and compared with those of others. The manner in which the data may be applied to Dragon reactor calculations is indicated. Local heat transfer coefficients and average friction coefficients were determined. (M.C.G.)

**10812** MEASUREMENT OF VOID FRACTIONS IN PARALLEL ROD ARRAYS. Richard A. Condon and Neil C. Sher (Allis-Chalmers Mfg. Co., Milwaukee). Nucl. Sci., Eng., 14: 327-38(Dec. 1962).

A study was conducted to establish the suitability of the gamma attenuation method for measuring void fractions in a parallel rod array. A lucite mock-up was used to evaluate the accuracy of the method; the error was found to vary from 7 to 13% depending upon the measuring method. Data were taken on an air-water system flowing vertically upward at atmospheric pressure, and were found to agree reasonably well with similar data for rectangular channels and round tubes. (auth)

**10813** PHYSICOCHEMICAL HYDRODYNAMICS. Veniamin G. Levich. Prentice-Hall International Series in the Physical and Chemical Engineering Sciences. [Translation of "Fiziko-Khimicheskaya Gidrodinamika." published by State Publishing House for Physics and Mathematical Literature, Moscow, 1959]. Englewood Cliffs, N. J., Prentice-Hall, Inc., 1962. 716p. (AEC-tr-5555)

A text is presented in which aspects of physicochemical hydrodynamics are treated by computation methods employed in theoretical physics. Physicochemical hydrodynamics is an approach in which aggregate aspects of the effects of fluid flow on chemical or physicochemical transformations are studied. The book is presented to systematize concepts of physicochemical hydrodynamics. Chapters are included which are concerned with convective diffusion in liquids, diffusion rates in turbulent flow, heat transfer in fluids, coagulation of gas-liquid dispersions, electrolytic solution conductivity mechanisms, motion induced by capillarity, motion of drops and bubbles in fluid media, motion of particles in electrolytes, polarographic theory, liquid surface waves, and motion and diffusion in thin liquid films. (J.R.D.)

## Materials Testing

*Refer also to abstract 11304.*

**10814** (ANL-FGF-335) NEUTRON RADIOGRAPHY — A NEW DIMENSION IN RADIOGRAPHY. Harold Berger (Argonne National Lab., Ill.). Mar. 1962. Contract [W-31-109-eng-38]. 20p. (UAC-6280)

The potential advantages of neutron radiographic inspection methods for metals are discussed. Primarily these advantages are associated with the relative differences in the absorptive properties of materials for neutrons as compared with gamma or x rays. These absorption differences can be used in many cases to obtain improved discrimination between several materials which may be present in an object under inspection. In addition, because of the higher transmission of thermal neutrons through most heavy metals, there are advantages to be gained in employing neutron techniques for the inspection of such materials. A comparison of neutron and other radiographic inspection methods for the inspection of U, in particular, is given. It is shown, using available neutron sources, both radioactive and accelerator, that significant gains in exposure time can be achieved over most other radiographic

equipment. Using a reactor neutron source, the speed of the neutron inspection method would surpass that of a 22 Mev betatron for U radiography. It is also shown that these gains can be achieved while maintaining high image quality, since contrast sensitivities in the order of 1 to 2% were obtained. (auth)

**10815** (TID-16062) EDDY CURRENT TESTING. SECTION I. THEORY. [W. R. Plant]. (Knolls Atomic Power Lab., Schenectady, N. Y.). [June 21, 1962]. Contract [W-31-109-eng-52]. 51p.

A review of the theory and technology of eddy-current testing is presented. Included are discussions of theory, measuring and recording instrumentation, and industrial practices in eddy-current testing. It is noted that the method is achieving increasing stature especially in the area of small-diameter tubes and bars having rigid quality requirements. (J.R.D.)

**10816** (USNRDL-TR-602) A CONTINUOUS SCAN SCINTILLATION SYSTEM FOR THE INSPECTION OF TUNGSTEN BILLETS. H. A. Zagorites and K. F. Sinclair (Naval Radiological Defense Lab., San Francisco). Dec. 10, 1962. 27p.

A continuous scan system, employing a 200-curie $Co^{60}$ source, scintillation detection of transmitted radiation, differential d-c amplification, and strip-chart recording, was applied experimentally to the inspection of tungsten billets used in the fabrication of nozzles for solid propellant rocket motors. The results of a detailed inspection of an uninfiltrated billet, supplied during the first phase of a round robin among a manufacturer and several Navy laboratories, were in agreement with radiographic data obtained during an earlier inspection. With this billet, the volume sensitivity of the system was measured to be about $5.0 \times 10^{-2}$ $cm^3$, which was within a factor of two of the predicted sensitivity of $2.7 \times 10^{-2}$ $cm^3$. The experimental work showed the feasibility of the continuous scan method as a primary inspection method for the inspection of tungsten billets and clearly demonstrated its usefulness in the present state of development as a supplement to film radiography. (auth)

**10817** CESIUM-137 IN $\gamma$ RADIOGRAPHY. E. Schiebold and E. Becker (Technische Hochschule Otto von Guericke, Magdeburg, Ger.). Isotopen Tech., 2: 264-9(Sept. 1962). (In German)

The use of $Ce^{137}$ as a $\gamma$ source for the nondestructive testing of steel was discussed. (J.S.R.)

**10818** HANDLING DEVICES FOR SPECIAL TEST PROBLEMS OF $\gamma$ RADIOSCOPY. E. Becker, F. Vorsprach, and W. Busse (Technische Hochschule Otto von Guericke, Madgeburg, Ger. and VEB Schwermaschinenbau Ernst Thalmann, Madgeburg-Buckau, Ger.). Isotopen Tech., 2: 292-5(Oct. 1962). (In German)

The construction of four handling devices for single object and panoramic exposures was described, and their operation was explained. The isodose curve and the special insertion possibilities for the device were given. (tr-auth)

# GEOLOGY, MINERALOGY, AND METEOROLOGY

**10819** (AD-278217) VELA UNIFORM PROGRAM. Semi-Annual Technical Report No. 1, November 1961–April 1962. (Itek Labs., Palo Alto, Calif.). May 31, 1962. Contract AF33(657)-7381. 142p.

Airborne sensors, covering the spectrum from 0.5 to 5.0 microns, are being designed on the predication that underground explosions will produce surface manifestations. Typical of such expected manifestations are reflectance changes in vegetation, soil density changes, and fracture patterns and/or soil disturbances produced directly by physical shock and vibration. Sensors for the system include a nine-lens spectral camera, color film cameras, spectrometers, and a cartographic camera. Design of the airborne and data reduction equipment is well advanced and fabrication of many items has begun. Photographic techniques, film and filter response curves, and data handling procedures were pursued. A test plot for photographing certain species of plants under controlled environmental changes was established and sequential photographic exposures are being taken. (auth)

**10820** (BNL-6554) TRANSPORT OF FISSION PRODUCTS THROUGH THE SOIL FOLLOWING INJECTION FROM A WELL AND METHODS USED FOR REMOVAL. L. Gemmell and S. G. Pearsall (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT-30-2-GEN-16]. 18p.

In the summer of 1960 one of the wells on the Brookhaven National Laboratory site became accidentally contaminated with radioactive material. Procedures used in tracking the spread of the contamination through the soil are described. Data are presented on the radioactivity in water from test wells and soil samples taken over a 2-year period. In 1961 approximately 227,000 gal of water were pumped from the test wells, decontaminated by means of an ion exchange column, and returned to the environment. The cost of this decontamination was approximately 1.06 mills/gal. (C.H.)

**10821** (GA-2985) A PROGRAM OF RESEARCH FOR THE DETERMINATION OF RARE-EARTH ELEMENTAL ABUNDANCES IN METEORITES. Quarterly Progress Report, March 15, 1962. R. A. Schmitt (General Atomic Div. General Dynamics Corp., San Diego, Calif.). Mar. 12, 1962. Contract NASr-75. 20p. (N62-10371)

The concentrations of the rare earth elements (La to Lu and Sc in meteorites were determined by neutron activation analysis in two hypersthenic chondrites, Hollbrook and Kyushu, in one Ca-poor achondrite, Johnstown, and in a peridotite. Abundance of Ce in Holbrook was the only variation in concentrations between the two chondrites. For the first time fractionation of the rare-earth elements was found in a meteorite, namely, the Ca-poor achondrite. Johnstown seemed to agree with those of ordinary chondrites. There was an enrichment of the heavier elements, Dy through Lu. Enrichment of Y and Sc occurred also. Analysis of the peridotite showed a relative monotonic depletion of only the light rare-earths (La through Eu) compared with ordinary chondrites. The agreement between meteoritic and terrestrial isotopic ratios $Ga^{158}-Ga^{160}$, $Er^{168}-Er^{170}$, and $Yb^{168}-Yb^{174}$ leads to the assumption that meteoritic matter and terrestrial matter have identical compositions (or a common origin of matter). (auth)

**10822** (HW-SA-2566) HANFORD EXPERIENCE IN THE RADIOLOGICAL MONITORING OF GROUND WATER. D. J. Brown and J. R. Raymond (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 1, 1962. Contract AT(45-1)-1350. 23p.

Investigations of ground water hydrology and water monitoring methods were needed in order to study the behavior of wastes discharged to ground. A discussion is presented of some of the monitoring methods and ground water flow concepts developed at Hanford. A brief description is given of the radiochemical techniques and evaluation methods. (D.L.C.)

**10823** (NP-12445) ARMADILLO. LRSM Final Report. Job Assignment 6-62. (Geotechnical Corp., Garland, Tex.). July 30, 1962. Contract AF33(600)-41694. 120p.

Information on travel times and amplitudes of the principle phases generated by the ARMADILLO detonation are presented in both tabular and graphic form. Both visual and machine analyses were made. (M.C.G.)

**10824** (NP-12462) GNOME SEISMOGRAM ALBUM. VESIAC Special Report. (Michigan. Univ., Ann Arbor. VELA Seismic Information Analysis Center). Dec. 1962. Contract SD-78. 135p.

A compilation of GNOME seismograms, collected from stations in the United States (including Alaska), Canada, Sweden, and Finland is presented. The records were chosen as typical for different geographic regions of the northern hemisphere. Information about the seismograms, e.g., station and instrument data, was included when available. The geographical distances at which the GNOME seismic signal was recorded are shown. (auth)

**10825** (NP-12465) NEW MADRID EARTHQUAKE. Long Range Seismic Measurements of VELA UNIFORM Project 8.4. (Geotechnical Corp., Garland, Tex.). Feb. 2, 1962. 29p.

Data obtained from seismograms of the New Madrid, Mo., earthquake on Feb. 2, 1962, are presented. The data were obtained at long-range seismic measurement stations throughout the U. S. from film records and from magnetic tape records. A description is included concerning seismic instrumentation and data reduction methods. (J.R.D.)

**10826** (TID-17722) A SURVEY OF THE OCEANOGRAPHIC LITERATURE OF THE SANTA BARBARA CHANNEL AREA. William Aron, William D. Clarke, Robert G. Paquette, Theodore C. Tutschulte, and Dale E. Well (General Motors Corp. Defense Research Labs., Santa Barbara, Calif.). Dec. 1962. Contract AT(11-1)-1145. 235p.

Approximately 1000 references concerning the oceanographic literature of the Santa Barbara Channel area are listed and annotated. The present state of oceanographic knowledge for the region is reviewed and the significant gaps in our knowledge, particularly those that apply to the disposal of radioactive isotopes, are indicated. (auth)

**10827** SPECTROGRAPHIC DETERMINATION OF BERYLLIUM IN THE GRANITE DIORITES OF MOUNT CAPANNE (ELBA) AND OF THE ISLAND OF GIGLIO. N. Coradossi and F. Tonani. Atti Soc. Toscana Sci. Nat. Pisa, Proc. Verbali Mem., Ser. A, 68: 1-22(1961). (In Italian)

Beryllium is distributed in granite partially in the form of concentrates and partially in the form of homogeneous dispersions. Any Be enrichment is associated with a corresponding boron enrichment. (tr-auth)

**10828** EFFECT OF THE VERY HIGH ALTITUDE THERMONUCLEAR EXPLOSION OF JULY 9, 1962, ON THE RESONANCE OF THE EARTH-IONOSPHERE CAVITY. Roger Gendrin and Robert Stefant (Centre National de la Recherche Scientifique, Orsay, France). Compt. Rend., 255: 2273-5(Oct. 29, 1962). (In French)

Since the first analyses made on the sonagram of the resonance of the earth-ionosphere cavity (Compt. Rend., 254: 1852(1962)), the methods of analysis have been modified so as to obtain the energy spectrum with precision. This method, applied to the recordings of July 9, 1962, has shown a sharp decrease of the resonance frequencies after the American thermonuclear explosion. (tr-auth)

**10829** REMARKS CONCERNING THE ESCAPE MECHANISM OF RADIOGENIC GASES. A. P. Vinogradov. Geokhimiya, No. 12, 1108(1962). (In Russian)

There is a general tendency to assume that the escape mechanism of radiogenic gases, such as argon, may be completely explained by the exposure of the minerals to high temperatures which can be calculated from the radiochemically determined age of the minerals. The $Ar^{40}/K^{40}$ method of age determination usually yields lower values than the method based on $Sr^{87}/Rb^{87}$; these lower values indicate the age of the metamorphosis of the rock, during which the gas escaped. However, it should be kept in mind that the metamorphosis of the rocks takes place at lower temperatures than those considered for the diffusion of Ar in the minerals; in addition, it is possible that minerals with completely different crystalline structure may have existed previously. This problem will be kept open for theoretical discussion until new experimental facts become available. (TTT)

**10830** DETERMINATION OF THE ACTIVATION ENERGY SPECTRA IN CASE OF THE ESCAPE OF ARGON AND HELIUM FROM MINERALS. E. K. Gerling and I. M. Morozova. Geokhimiya, No. 12, 1108-18(1962). (In Russian)

Previous studies of geological age determination indicated that a larger energy of activation of the Ar points toward a lower probability that the gas can pass through the mineral, thus toward an increased probability that it will be held throughout the geological existence of the mineral. This energy of activation may be obtained by determining the kinetics of the escape mechanism of the gas from the mineral at various temperatures. The calculations showed that the dimensions of particles through which the gas diffuses are much smaller than the actual dimensions of the samples. The diffusion constant D cannot be measured directly; measurements yield only the value of the expression $D/a^2$, where a is the crystal radius. Strongly deteriorated minerals yield a complex curve, containing a whole spectrum of activation energies. The energy of activation involved in the escape of He from monazite is about 53,000 cal. In the case of uraninite 2 maxima were found, at 12,000 and 20,000 cal. The escape of Ar from the Perti-Baraka mica layer was found to have a maximum of the activation energy at 93,000 cal. These data, obtained by an isothermal annealing technique, agree well with the authors' previous findings. (TTT)

**10831** A PROPOS OF E. K. GERLING'S REMARKS. S. B. Brandt. Geokhimiya, No. 12, 1118-22(1962). (In Russian)

In all his previous works, starting with his thesis in 1939, E. K. Gerling is said to commit the error of dividing the radiogenic argon content of minerals in areas on the basis of the energy of activation of the diffusion process. He assumed thereby that at the start of the measurements the specimen contains 100% of the diffusing material but he also made use of Greenberg's formula for determining the residual material. A reconsideration of the problem is presented that shows that the diffusion equation of radiogenic occlusions is similar to the expression derived by Darken for the Kirkendall effect. The latter involves the formation of voids and porous regions, similar to metamict structures, from which radiogenic gases may escape quite easily. (TTT)

**10832** DATING THE PAST WITH RADIOACTIVITY. Intern. At. Energy Agency Bull., 5: 18-21(Jan. 1963).

A review is given on dating the past in geology and meteorology with radioactivity. Discussion is given on methods and possibilities and applications in the earth sciences, such as the movements of air and water masses, the origin and nature of rock formations, and the history of meteorites. (P.C.H.)

**10833** NEUTRON-NEUTRON WELL LOGGING THEORY. I. EPITHERMAL NEUTRON DISTRIBUTION IN THE CYLINDRICAL GEOMETRY. Jan A. Czubek (Inst. of Nuclear Research, Polish Academy of Sciences, Krakow). Nukleonika, 7: 745-58(1962). (In English)

The solution of the age equation is given for cylindrical geometry, when the point neutron source is in the origin of the coordinates, and the boundary of two media is the lateral surface of the cylinder. (auth)

**10834** APPARATUS USED IN THE LABORATORY OF ABSOLUTE GEOCHRONOLOGY FOR DETERMINING THE AGE OF SAMPLES BY THE $^{14}C$ PROCEDURE. Wlodzimierz Moscicki and Andrzej Zastawny (Inst. of Nuclear Research, Polish Academy of Sciences, Gdansk). Nukleonika, 7: 801-17(1962). (In English)

A description of radiocarbon dating laboratory equipment is given. A proportional counter of about 2.5-l effective volume, filled with pure $CO_2$ at atmospheric pressure, is used as a detector. When employing common shields the background counts are 15.14 cpm, whereas contemporary carbon yields 18.34 cpm. With the discrimination threshold set on 10 mv the slope of detector plateau is 0.9%/100 v for background pulses, 0.5%/100 v for $C^{14}$ decay electrons and 0.3%/100 v for cosmic rays. The theoretical maximum age is about 36,000 years. The method of statistical analysis of the data is discussed. (auth)

**10835** STRONTIUM-90 IN ATLANTIC SURFACE WATERS. N. I. Popov, E. G. Azhazha, G. I. Kosourov, and A. A. Yuzefovich. Okeanologiya, No. 5, 845-8(1962).

Samples of surface sea water collected from 14 stations between the English Channel and the Bahamas and northward along the North American coast during the fall-winter season of 1959–1960 were analyzed for $Sr^{90}$ content. The data, combined with those obtained for the 1954-1960 period, show that the total $Sr^{90}$ fallout over the area was 15 times greater in 1960 than in 1954. However, Russian data for this area show that there was only a slight variation in the $Sr^{90}$ concentration in the surface waters, indicating that it had been effectively removed by some means. The American view that there is a vertical exchange is accepted. Russian data indicating that the scatter in known $Sr^{90}$-concentration values in the surface waters is not large are considered to be evidence that despite favorable conditions for mixing and motion in the upper layers, $Sr^{90}$ concentration does not level off rapidly. It is stated that current information is not adequate to pinpoint any connection between $Sr^{90}$ distribution and the locations of oceanic currents. (OTS)

**10836** DEVELOPMENT AND TESTING OF AN ELECTRODE FOR NEUTRON-NEUTRON AND NEUTRON-

GAMMA RADIOACTIVE LOGGING. V. Comănescu, M. Oncescu, P. Sandru, and A. Topa (Inst. of Nuclear Physics, Bucharest). Rev. Phys., Acad. Rep. Populaire Roumaine, 7: 455-65(1962). (In English)

A probe containing $BF_3$ counters and G-M counters is designed for natural-$\gamma$, (n,$\gamma$), and (n,n) logging of drill holes. The probe is used with a Po-Be neutron source, is capable of long-term operation (12 hr continuous use), and has electronic circuitry that permits changes in the mode of operation (gamma detection to neutron detection and vice versa) without removing the probe from the hole. The probe is found to operate at maximum efficiency for minimum source-detector distances and for off-center positioning of the probe in the hole. (T.F.H.)

**10837** PROPAGATION OF AIR WAVES FROM NUCLEAR EXPLOSIONS. William L. Donn, Richard L. Pfeffer, and Maurice Ewing (Columbia Univ., New York). Science, 139: 307-17(Jan. 25, 1963).

An examination of low-frequency pressure waves generated by large thermonuclear explosions provided data on the relation of air wave propagation to atmospheric structure. These waves can be detected days after the time of detonation. Because these waves travel under the joint influence of the acoustic properties of the atmosphere and gravity, they are called acoustic-gravity waves, in distinction to pure acoustic waves and pure gravity waves. Information as to how they are propagated and detected as well as the theory behind these processes were included in order to predict theoretically the observed properties of the waves described and to gain an understanding of the mechanisms by which the waves propagate. Methods of making frequency analyses with respect to seismograms were applied to the analysis of pressure records from nuclear explosions. (C.E.S.)

**10838** METEORITE WITH UNIQUE FEATURES. H. H. Nininger (Meteorite Investigations, Sedona, Arizona). Science, 139: 345-7(Jan. 25, 1963).

A brief account of the discovery in Luzon, Philippines, of a large meteorite that does not fit into any of the currently used classifications is presented; together with results of preliminary studies of its unprecedented structure, specific gravity, and multiple magnetic polarity. Its probable terrestrial age is also discussed. (auth)

**10839** $\gamma$ SPECTROSCOPIC INVESTIGATIONS ON STONE METEORITES. C. Mayer-Boericke, M. M. Biswas, and W. Gentner (Max-Planck-Institut für Kernphysik, Heidelberg). Z. Naturforsch., 17a: 921-4(Oct. 1962). (In German)

Cosmic-ray-produced $Al^{26}$ and $Na^{22}$ activities in chondrites were studied by nondestructive $\gamma$(511 kev)-$\gamma$ coincidence spectroscopy. The values of the $Al^{26}$ specific activities of the four measured hypersthene chondrite samples are nearly equal, and have a mean value of 0.061 $Al^{26}$ $e^+$ decays/min g. The $Na^{22}$ specific activity of the Bruderheim chondrite was found to be 0.094 $Na^{22}$ disint/min g in agreement with the results obtained by other authors using different methods. From the $Na^{22}$ activity and the $Ne^{22}$ content of our sample, a cosmic ray exposure age of $26 \times 10^6$ y for Bruderheim was calculated. Exposure ages of other chondrites are discussed. Single crystal $\gamma$ spectroscopy of Bruderheim shows, in addition to $Al^{26}$ and $Na^{22}$, the presence of $Mn^{54}$ and $K^{40}$. (auth)

**10840** MEASUREMENT OF THE TRITIUM CONCENTRATION PATTERN IN RAIN IN 1960-61 BY ISOTOPIC ENRICHMENT IN THE SEPARATION PERIOD. Gerhard W. Israel (Universität, Heidelberg). Z. Naturforsch., 17a: 925-9(Oct. 1962). (In German)

The tritium content in rain water collected near Cologne (Germany) varied in 1960–61 between 20 to 200 TU with the maximum in May and the minimum in November. A striking parallel with variation of Sr-90 in rain is found. About 10 ml of rain water are reduced by magnesium. The tritium is quantitatively enriched by a Clusius-Dickel-column in 24 hours. A tenfold electrolytical enrichment is done beforehand when measuring tritium concentrations less than 20 TU. The performance of the CD-column is found to be in good agreement with theory. The activity is measured by an argon-methane filled proportional counter, whose background is reduced by energy discrimination. (auth)

**10841** PROBLEMY RADIOGEOLOGII. (Problems in Radiogeology). L. V. Komlev, ed. Moscow, State Publishing House of Scientific-Technical Literature on Geology and Conservation of Natural Resources, 1961. 351p.

An extensive survey was made of the problems in radiogeology and absolute geochronology. The book is divided into chapters dealing with the basic studies of radioactivity and atomic nuclei in nature, earth radioactivity and cosmic bodies, primary radiological methods for determining geological time, lead isotopes in the earth's crust and lead age estimation, secondary radiological age estimating methods, determination of earth and meteorite age, evaluation of basic geological processes, and nuclear processes in the earth's crust. A comprehensive list of references is included. (R.V.J.)

**10842** TEORIYA PODOBIYA I RADIOMETRIYA SKVAZHIN. (The Theory of Similarity and Radiometry of Bore-Holes). Sh. A. Guberman. Moscow, Gostoptekhizdat, 1962. 108p.

Particle transport theory was applied to bore-hole radiometry. The obtained data were generalized for various radiometric problems. The boon was designed for scientists and engineers studying applications of nuclear emissions. 65 references are included. (R.V.J.)

# HEALTH AND SAFETY

*Refer also to abstract 10522.*

**10843** (BNL-6538) THE STATUS OF METEOROLOGICAL KNOWLEDGE AS A FACTOR IN AIR POLLUTION CONTROL. Maynard E. Smith (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT-30-2-GEN-16]. 21p.

An outline of the availability status of meteorological knowledge and a review of its use in air pollution problems are presented. Information is included concerning individual pollutant sources, effects of terrain and vegetation on pollution concentrations, deposition factors, multipollutant sources, and large area pollutant sources. (J.R.D.)

**10844** (CEA-Bib-29) ETUDES DE L'ARRET DE L'IODE 131. (Studies on $I^{131}$ Stopping). G. Chevalier (France. Commissariat a l'Energie Atomique. Centre d'Etudes Nucleaires, Saclay). 1962. 24p.

A review of $I^{131}$ trapping is given. The physical states of I in the atmosphere, production procedures, and sampling and detection methods are briefly described. The stopping of $I^{131}$ by different types of traps is examined. The metallic traps (columns filled with Cu and Ag) and the activated coals are considered. Some industrial filters are described; they use only activated coal or a combination of dust filter papers and coal filters. (auth)

**10845** (CEX-62.2) NUCLEAR BOMB EFFECTS COMPUTER, (INCLUDING SLIDE-RULE DESIGN AND CURVE FITS FOR WEAPONS EFFECTS). E. Royce Fletcher, Ray W. Albright, Robert F. D. Perret, Mary E. Franklin, I. Gerald Bowen, and Clayton S. White (Lovelace Foundation for Medical Education and Research, Albuquerque, N. Mex.). Apr. 1962. Contract [AT(29-1)-1242]. 80p.

Based on data from the 1962 edition of The Effects of Nuclear Weapons, a circular slide rule was designed to evaluate 28 different effects of nuclear weapons. Of these 28 different effects, 13 relate to blast, 5 to thermal radiation, 1 to initial nuclear radiation, 2 to early fallout, 6 to crater dimensions, and 1 to fireball dimensions. Most of the parameters are presented as functions of range and yield (1 kt to 20 Mt). Techniques are described which make it possible to estimate most of the effects parameters for yields greater than 20 Mt or smaller than 1 kt. The report presents curve fits of weapons-effects data, design analysis for the slide rule, and instructions for use of the rule along with some of the implications of the data in regard to biological and structural damage. The machine techniques are mentioned which were used to prepare the original graphs necessary for the production of the slide rule. (auth)

**10846** (HW-61840) SURVEY OF AIR AND GAS CLEANING OPERATIONS. A. C. Morgenthaler (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Sept. 1, 1959. Contract [AT(45-1)-1350]. 22p.

An informative summary of air and gas cleaning operations in the Chemical Processing Department of the Hanford Atomic Products Operation, Richland, Washington, is presented. Descriptions of the fundamental components of cleaning systems, their applications, and cost information are included. (H.G.G.)

**10847** (HW-73337) RESEARCH AND DEVELOPMENT ACTIVITIES IN THE RADIOLOGICAL SCIENCES– PHYSICAL SCIENCES PORTION, JANUARY THROUGH DECEMBER 1961. R. L. Junkins and J. E. Brown, eds. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Jan. 15, 1962. Contract AT(45-1)-1350. 308p.

Separate abstracts were prepared on 5 sections of this report. (C.H.)

**10848** (HW-73337(p.1-28)) ATMOSPHERIC PHYSICS. C. L. Simpson, C. E. Elderkin, et al. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

Micrometeorological research was continued on problems associated with predicting the dosage levels and concentrations in the environment of contaminant materials released to the atmosphere. A diffusion model is described that accounts for the wind direction shear with height in the lower layers of the atmosphere. Results of recent deposition experiments, using ZnS particulate tracer material, are summarized. A method is described for determining vertical exchange coefficients for matter in the surface layer of the atmosphere by using results of diffusion and deposition experiments. A raindrop sampler is described and raindrop spectra are presented. Probable mechanisms by which microscopic particles are scavenged from air are reviewed. (C.H.)

**10849** (HW-73337(p.29-76)) RADIOLOGICAL PHYSICS. H. E. Palmer, F. Swanberg, Jr., et al. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

The calibration of a shadow shield whole-body counter is described. A 3- by 3-in. NaI scintillation counter was proven capable of detecting as low as approximately 17-nanocurie (nc) amounts of $I^{131}$ in the human thyroid. The sensitivity of several detectors for external thyroid counting was compared. Data are tabulated on the effects of the consumption of one quart of milk per day on the amount of $I^{131}$ in the thyroid gland of residents of the northwestern U. S. in 1961. Factors influencing the efficiency and accuracy of Pu measurements in wounds by thin crystal x-ray scintillation spectrometry are discussed. The body retention and distribution of inhaled $Co^{60}$ and $Sb^{125}$ from particulate contamination are discussed. Factors affecting the sensitivity of a precision lung counter and the effects of $\gamma$ radiation on brass $BF_3$ tubes used in the counter are discussed. Recent data are presented that show directly the neutron energy degradation in a Pu-Be source and show the presence of a low energy group in the Pu-Be neutron spectrum. Estimates of the rate of increase in neutron emission are reported for four Pu-Be sources. Two methods are described for providing sources whose rates of emission change are known. A large moderator is described that can be used for studying neutron emission from $(\alpha,n)$ or $(\gamma,n)$ sources or for obtaining a small flux of thermal neutrons. Improved techniques are described for the preparation of carbon targets for the 2-Mev Van de Graaff accelerator. Factors contributing to target contamination are discussed. Examples of ozone production during experiments with a Van de Graaff accelerator are described and hazards to operators are discussed. An improved value for the half-life of $Sb^{124}$ was determined using a high-precision calorimeter. A method of using a small source of heat to cause a much larger change in an auxiliary heat source is described. Applications of heat amplifiers in calorimetry are discussed. The energy required to produce an ion pair in air was determined for $Co^{60}$ from a combination of calorimetric and ionization measurements. (C.H.)

**10850** (HW-73337(p.77-157)) RADIOLOGICAL CHEMISTRY. C. W. Thomas, L. J. Kirby, et al. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

Radiochemical procedures are described for the determination of $Sc^{46}$ and $Cs^{137}$ in water samples, the determination of $Pd^{109}$ and $Pd^{112}$ in mixed fission products plus Pu, the determination of rare earth and Y isotopes in samples containing mixed fission products and Pu, the determination of Sb isotopes by $\gamma$ scintillation counting, the determination of Cd isotopes in samples containing mixed fission products and Pu, the determination of U in water, and the determination of tritium in water. Gamma ray spectrometric methods were investigated with the aim of optimizing both sensitivity and selectivity in radioisotope measurements. A four-chamber proportional counter was built with very thin windows to detect weak $\beta$ radiation in an external gas cell. Silicon surface barrier diode detectors were compared with Frisch grid ion chambers for $\alpha$ energy analysis. The diode detectors were found to be especially useful where greater $\beta$ tolerance, lower background, or lower initial investment are important requirements. Introductory electron spin resonance measurements on irradiated radish seeds showed that the signal intensities leveled off with increasing dose and decreased more rapidly at higher temperatures than at lower temperatures over a span of time. A small ERS signal was also obtained from unirradiated radish seeds. Radioinduced hemolysis of red blood cells was found to be inhibited by a variety of compounds added to the cell suspensions prior to irradiation. A mechanism was developed that quantitatively describes the process in terms of successive attacks on the cells by free radicals produced in the radiolysis of the surrounding water. The efficiencies of compounds in protecting cells from hemolysis was found to be directly related to their rates of reactions with these radicals. The binding of the dyes crystal violet, bismarck brown, and erioglaucine by human red cells was investigated. Significant amounts of the first two dyes were bound by the cell surface. No binding of erioglaucine was observed, nor was any diffusion into the cell detected. As erioglaucine is very effective in protecting the cell from radioinduced hemolysis, this observation led to speculation that the site of free radical damage that ultimately leads to hemolysis is on the exterior surface of the cell. Gaseous $CF_2Cl_2$ (Genetron-12) and $CHF_2Cl$ (Genetron-22) in aqueous solutions were found to decompose into hydrogen, chloride, fluoride, and bicarbonate ions following $\gamma$ irradiation. Preliminary studies of Columbia River sediments with regard to their radioisotope content, particle size distribution, and mineralogical composition are described. Age estimates were made of the sediment layers of a river core sample based on the ratios of the artificial radioisotopes in the different core layers. The concentrations of certain chemical elements in the Columbia River were measured by activation analyses of salts from water samples. Preliminary results are reported from a study undertaken to determine the effects of ground cover and vegetation on meteorological diffusion of particulates in the atmosphere. Methods were developed that allow removal and quantitative measurement of dispersed particles from vegetation. The usefulness of the ferrous-permanganate system as a water treatment process for the removal of trace ions was demonstrated using radioactive tracers. The optimum alum feed rates for reactor water treatment were determined for Columbia River water. (C.H.)

**10851** (HW-73337(p.158-237)) CHEMICAL EFFLUENTS TECHNOLOGY. J. L. Nelson, L. L. Ames, Jr., et al. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

Equations for the prediction of ion exchange column breakthrough curves were modified to insure more consistent results for soil columns of different lengths. An exchange column of pebble phosphate was found to absorb Pu from slightly acidic wastes. The uptake of certain radioisotopes present in spent cooling water from reactors by selected minerals was determined at 80°C. Data are tabulated on the absorption of $P^{32}$, $As^{76}$, $Np^{239}$, $Zn^{65}$, and $Cr^{51}$ by 25 minerals. Additional studies on $P^{32}$ adsorption by 21 minerals and by mixed mineral beds were carried out. The efficiency of Al turnings for the decontamination of reactor effluent was investigated on pilot-scale beds. A scheme is described for overcoming the computational problem in field permeability measurements on soil. An approximate method is presented of computation for in-place permeability measurement and basic equations are presented to describe steady, partially saturated flow in porous media. Results are reported from recent studies on geologic features and ground water flow at the Hanford Area. The disposal of decontamination wastes from the New Production Reactor to ground at an inland site is discussed. A logging system for well water temperature measurements and a flow meter for measuring vertical currents in wells are described. The effects of temperature and air velocity on uranium oxide particulate production and entrainment and the fractional release of fission-product elements from irradiated uranium during reactor disaster conditions were investigated. The percent release of purified $Sr^{89+90}$, $Ce^{141+144}$, and $Cs^{137}$ from their respective chemical shipping forms is presented for postulated accidental firing conditions. An analysis was made of thermal deposition of particles in circular ducts based on a simplified model and an equation derived that expresses the resulting change in particulate concentration. (C.H.)

**10852** (HW-73337(p.238-97)) INSTRUMENTATION. M. O. Rankin, D. P. Brown, et al. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

A scintillation detection instrument, using coincidence counting techniques, was developed to measure $Pu^{239}$ air concentration levels. An instrument was developed to sample and monitor filtered hot cell exhaust gases for radioactive particles. The system will alarm in less than 19 min if the airborne concentrations of mixed fission product $\beta$ emitters exceed $6.2 \times 10^{-9}$ $\mu$c/cc or if $\alpha$ emitter concentrations exceed $1.2 \times 10^{-11}$ $\mu$c/cc. A self-powered radiation monitor and analyzer instrument was developed for use in field studies. All circuitry is solid state for low power dissipation and reliable operations. Transistorized test pulse generator and count-rate circuits are incorporated in the instrument. An area radiation monitor that incorporates both logarithmic and multidecade linear ranges was developed. Block diagrams of all instruments are presented. Two experimental pocket-size radiation dosimeters were developed. One alarms audibly after a predetermined dose is accumulated and the other provides a digital indication of the received dose on a miniature register. The optical properties of $CaF_2$:Mn were investigated in connection with the development of thermoluminescent dosimeters. Experimental solid state surface barrier detectors were fabricated from single crystals of silicon. Several experimental diodes were tested in portable $\alpha$ survey instruments. A monitor for detecting Pu in wounds was developed, fabricated, and tested. A transistorized operational amplifier was developed to drive a chart recorder from a count-rate meter. A pulse height selector circuit using tunnel diodes was developed for use in both portable

and line-operated radiological monitoring instruments. An annunciator, producing a standard sound wave in a short closed pipe, was developed for use with portable radiation monitoring instruments. A scintillation beta-gamma monitor for counting hands, shoes, and clothing was developed and fabricated. An instrument system for automatically reading personnel dosimeter films was fabricated and tested. An IBM printing card punch records the information on a standard IBM card and copies common information, such as date and work area, from card to card. (C.H.)

**10853** (HW-SA-2518) THE POTENTIAL HAZARDS OF SHIPPING GROSS QUANTITIES OF RADIONUCLIDES. E. C. Watson (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 29, 1962. Contract [AT(45-1)-1350]. 21p.

An evaluation of the consequences of an accidental release of $Sr^{90}$ and $Sr^{89}$ from the HAPO-IA cask was made assuming loss of radio-strontium to the atmosphere or to the surface water. Release to the atmosphere could result from a collision followed by fire or explosion. In the event of a fire, a small fraction of the radio-strontium would be volatilized. An explosion would disperse the $Sr^{89}$ and $Sr^{90}$ still adsorbed to Decalso as particulates. In either case, the material was assumed to be dispersed by atmospheric mechanisms which can be described by diffusion equations. It was estimated that about 70 square miles could become contaminated with $Sr^{90}$ to a level that would warrant concern if no remedial action were taken. The release of $Sr^{90}$ to a river would be of less consequence. (auth)

**10854** (HW-SA-2565) THE INTRODUCTION OF NEW AND IMPROVED METHODS FOR WORK IN RADIATION ZONES IN PRODUCTION REACTORS AT HANFORD. George A. Fox (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). [May 2, 1962]. Contract [AT(45-1)-1350]. 28p.

The techniques and equipment are described that were chosen and that have been successfully used in radiation protection by the Industrial Engineering Operation in the Manufacturing Section of the Irradiation Processing Dept., Hanford Atomic Products Operation, Richland, Washington. Complicating factors such as the remoteness of the work location, radiation, and communications problems are discussed. In addition to the conventional method of standardization and training, particular use is made of photographic means of describing work methods. Recent examples of applications of these techniques to our work are provided in slide form. In addition to the common use of movies for methods analysis and training, still photos are used extensively together with the written word for standardization of instruction and method. These methods improvement and training techniques have been used successfully and are believed to be useful elsewhere. (auth)

**10855** (HW-SA-2609) ELEMENTS OF EMERGENCY PLANNING FOR COPING WITH A SERIOUS RADIATION ACCIDENT. A. R. Keene, C. M. Unruh, G. E. Backman, and L. A. Carter (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). June 11, 1962. Contract [AT(45-1)-1350]. 22p.

Procedures are outlined for coping with serious radiation accidents. It is pointed out that accidents can occur in spite of careful facility design and conservative operating procedures and that advance planning should be done to handle the most severe accident that is credible without regard to the probability of its occurrence. Since the actual conditions encountered after an accident will differ from those in a postulated accident, plans should be kept general and flexible. (C.H.)

**10856** (NP-12351) SAMPLING OF AIRBORNE RADIOACTIVE PARTICLES BY ELECTROSTATIC PRECIPITATION (thesis). John Wesley Baker (Air Force Inst. of Tech., Wright-Patterson AFB, Ohio). May 1962. 138p. (GNE/Phys/62-2)

A report of an experimental study that was conducted to design, build, and test an electrostatic precipitator to determine the feasibility of fallout sampling by electrostatic precipitation is presented. A description of pertinent theory is provided, a detailed discussion of all parametric, experimental, and analytical studies is presented, and the resultant collector and collection facility and collection and analysis techniques are described. It is concluded that the electrostatic precipitation will provide a superior sample collection rate that might be increased even further by continued design studies, removal of collected particulates in a fluid bath would result in a selective solubility fractionation that would prevent an accurate concentration by filtration but would permit concentration by evaporation of the fluid, and electrostatic collection on a thin compactible, conducting plastic film would provide an optimum collection technique since the film could be advanced through the collector at periodic intervals to allow a continuous sampling capability and all of the sample could be contained in a good thin-disk sample geometry. (auth)

**10857** (NP-12427) AN ORDINANCE ON THE CONTROL OF RADIOISOTOPES AND THE LIKE AND SAFEGUARDS AGAINST RADIATION HAZARDS DUE TO RADIOISOTOPES. (Korea. Office of Atomic Energy, Seoul). [nd]. 66p.

Regulations on acquisition, import, export, use, sale, possession, concession, and receipt of radioisotopes including the use of particle accelerators, and also stipulating necessary standards or requirements on the handling and on installations using radioisotopes or particle accelerators are presented. (M.C.G.)

**10858** (NP-12466(Vol.I)) RAVENSWOOD NUCLEAR GENERATING UNIT A. Preliminary Hazards Summary Report. Volume I. (Consolidated Edison Co. of New York, Inc.). [1962]. 103p.

A summary is given of the general plans for the construction of Ravenswood, the site, plant description, safeguards, accidents, safety analysis, and the research and development program. Finally, the plant is described in detail. (D.L.C.)

**10859** (NP-12466(Vol.II)) RAVENSWOOD NUCLEAR GENERATING UNIT A. Preliminary Hazards Summary Report. Volume II. (Consolidated Edison Co. of New York, Inc.). [1962]. 87p.

The following items are discussed in detail: safeguards, accident analysis, control of radiation and wastes, and the research and development program. (D.L.C.)

**10860** (NP-12466(Vol.III)) RAVENSWOOD NUCLEAR GENERATING UNIT A. Preliminary Hazards Summary Report. Volume III. (Consolidated Edison Co. of New York, Inc.). [1962]. 70p.

Drawings for the hazards summary report are presented. The drawings cover the reactor plant design, fuel, heat transfer, coolant system, waste disposal system, containment, air filtration, site dose, effluent dilution, etc. (D.L.C.)

**10861** (NP-12467) RAVENSWOOD NUCLEAR GENERATING UNIT A. Site Data. (Consolidated Edison Co. of New York, Inc.). [1962]. 84p.

A detailed description is given of the site and adjacent areas, and aerial and panoramic photographs are presented. Reports are given on the meteorology, hydrology, geology,

and seismology of the site. The results of a radiation survey of the environment are given. (D.L.C.)

**10862** (RFP-290) DESCRIPTION OF A PLUTONIUM AND ENRICHED URANIUM SHIPPING CONTAINER AND INTEGRITY TESTS ON THIS CONTAINER. C. L. Schuske (Dow Chemical Co. Rocky Flats Div., Denver). Nov. 16, 1962. Contract AT(29-1)-1106. 10p.

The M-101 (an all steel) shipping container and safety cage was in use for about 15 years for transporting and storage of enriched U. With slight modifications and the addition of an inner container, the M-101 can be used to ship Pu metal. Various physical tests performed on the M-101 and inner container are described, and critical array sizes under various conditions of spacing and flooding are discussed. (auth)

**10863** (RSPP-20(Issue 1)) SAFE HANDLING OF ZIRCONIUM METAL AND ZIRCONIUM ALLOYS. RECOMMENDATIONS ON SAFETY PRINCIPLES AND PRACTICE, 1962. (United Kingdom Atomic Energy Authority. Authority Health and Safety Branch, Risley, Lancs, England). 6p.

Safe methods of handling zirconium and its alloys are discussed. Topics covered include: safety requirements in the design, construction, and equipment of plant, laboratories, and stores; safety requirements in the operation of plant, laboratories, and stores; special conditions applicable to the storage and disposal of zirconium waste; and transport of zirconium, including zirconium wastes. (M.C.G.)

**10864** (SCPRI(RM)62-9) RAPPORT D'ACTIVITE, SEPTEMBRE 1962. (Report of Activities, September 1962). (France. Service Central de Protection contre les Rayonnements Ionisants, Paris). 48p.

The results of the radiological monitoring of the atmosphere, nuclear sites, rain waters, and the food chain are summarized and shown graphically. (J.S.R.)

**10865** (SCPRI(RM)62-10) RAPPORT D'ACTIVITE, OCTOBRE 1962. (Report of Activities, October 1962). (France. Service Central de Protection contre les Rayonnements Ionisants, Paris). 53p.

The results of the radiological monitoring of the atmosphere, nuclear sites, rain waters, and the food chain are briefly summarized and shown graphically. (J.S.R.)

**10866** (TID-16203) DISASSEMBLY OF A HIGH LEVEL PLUTONIUM GLOVE BOX SYSTEM. James A. Johnson (Argonne National Lab., Ill.). May 1962. Contract [W-31-109-eng-38]. 27p. (UAC-6414)

Dismantling operations of the Pu Metallurgy Research Laboratory, first put into operation 7 years ago at Argonne National Laboratory, began in Sept. 1961. Multi-gram quantities of Pu and U had been handled in the 16 interconnected glove boxes that comprised the glove box train. All boxes were separated along with all systems located externally to the train which they served. The dismantling process required 8 weeks. Approximately 300 $ft^3$ of high-level-alpha dry waste was removed during this period along with hundreds of feet of contaminated and non-contaminated pipe and tubing, pumps, gauges, and regulatory devices. There were no incidents of internal or external radiation exposure during this period and only 1 incident of a gross spread of alpha contamination. (auth)

**10867** (TID-17769) ENVIRONMENTAL RADIATION MONITORING. Third Quarterly Report, July–September 1962. (Duquesne Light Co., Shippingport, Penna.). Contract [AT(11-1)-292]. 8p.

Data are tabulated on radioactivity in samples of rain water, river water, and air collected from July through Sept., 1962. The fallout radioactive material content continued to increase with the highest activity being recorded in Sept. (C.H.)

**10868** (UCRL-9967(Rev.)) NEUTRON DOSIMETRY IN AND AROUND HUMAN PHANTOMS BY USE OF NUCLEAR TRACK EMULSION. Hiroaki Akagi and Richard L. Lehman (California. Univ., Berkeley. Lawrence Radiation Lab.). Apr. 1962. Contract W-7405-eng-48. 46p.

The validity of the nuclear track emulsion technique for fast-neutron dosimetry was examined in the exposure of a human phantom to PuBe neutrons. Semiautomatic track scanning and high-speed data analysis obviated the major disadvantages of emulsion dosimetry and allowed the absolute differential proton track energy spectrum at various locations in the phantom to be obtained without a serious cost in time. From this the total absorbed local tissue dose due to proton recoils and the local thermal neutron intensity during irradiation were calculated. (auth)

**10869** (Y-KB-7) USE OF STATISTICS IN AN APPLIED HEALTH PHYSICS PROGRAM. C. M. West and J. P. Reavis (Union Carbide Nuclear Co. Y-12 Plant, Oak Ridge, Tenn.). [nd]. Contract W-7405-eng-26. 18p.

The use of statistics in the Y-12 Applied Health Physics Program is discussed. Included in the discussion are details of programs designed: to evaluate the precision and bias of various health physics analyses; to determine the optimum sampling frequency so as to maintain the appropriate balance between information obtained and program cost; and to assure that action criteria are used with a known and consistent degree of confidence. Adjustments in the Y-12 urinalyses program participation frequency during calendar year 1961, based on a statistical treatment of data and established criteria, resulted in a decrease of approximately 65% in the number of samples scheduled. A recent statistical evaluation of the general air sampling program resulted in an approximately 20% reduction in the rate of taking such samples. It is concluded that the judicious use of statistical studies and criteria is of great value in an applied health physics program. (auth)

**10870** (JPRS-16995) PROTECTION AGAINST RADIATION. E. (Ye.) Romantsev. Translated from p.1150-68 of "Bol'shaya Meditsinskaya Entsiklopediya" Vol. XXVI, Moscow, 1962. 31p.

General principles of protection against radiation are reviewed. Regulations of the U.S.S.R. covering maximum permissible radiation exposure for medical and research personnel are outlined. Various methods of radiation protection are discussed. (C.H.)

**10871** A TEN STATE STUDY OF THE STATUS OF RADIATION HYGIENE IN DENTAL OFFICES. Seymour H. Yale (Univ. of Illinois, Chicago). J. Am. Dental Assoc., 63: 201-10(Aug. 1961).

A survey was conducted of x-ray facilities in 2000 dental offices under actual operating conditions. Each of 10 dental schools in the United States collected data on 200 local dental offices to implement geographic analysis of the status of radiation hygiene in the offices. The data provided records of roentgen (r) output of each machine, relative r dose to patient, and dose to operator. In addition, specific information relating to both operator and machine was collected and evaluated. Some dentists were found to be operating under unsafe conditions, but the average dentist covered in the survey was statistically safe. On the basis of the survey, it was concluded that the problem of radiation hazards in dentistry will be resolved when all dental x-ray machines are properly filtered and collimated and high-speed dental x-ray film is used. (P.C.H.)

**10872** ACCIDENTAL DENTAL OCCUPATIONAL EXPOSURE TO IONIZING RADIATION. Jack Levin (Johns Hopkins Hospital, Baltimore). J. Am. Dental Assoc., 65: 331-4(Sept. 1962).

A case is reported of a 39-yr-old dentist who realized that his dental x-ray machine had been on for about 90 min. During this time he was near the machine constantly, with his back usually toward the source of radiation. The estimated dose to the back of his head and upper torso was 180 r. The dentist suffered some anxiety, but no acute symptoms of radiation sickness. Physical examination gave negative results. There was no evidence of acute radiation damage. Study of temporal scalp hair revealed an estimated maximum dose received by the hair follicles of ~50 to 75 r. The direct technical cause of the accident was a loose washer in the timer mechanism, making contact and completing the switching circuit, thereby causing the unit to go on. It is suggested that dentists and their assistants should wear radiation exposure badges at all times. In addition, equipment should be systematically and regularly checked so that maximum operating efficiency can be combined with minimum exposure. (P.C.H.)

**10873** AN APRON FOR X-RAY PROTECTION. H. G. Poyton (Univ. of Toronto). J. Can. Dental Assoc., 28: 149-51(Mar. 1962).

An apron that is adjustable for patients of all sizes, inexpensive, and easily laundered is described. It affords good protection to the gonadal region but does not protect other areas of the body. It is made of white linen or other similar material, $17\frac{1}{2}$ in. wide and 25 in. long. It is retained in position by a band passing behind the neck. It has a pocket 10 in. square and open at the top edge. Before use, a sheet of Pb 1 mm thick and 10 in. square is placed in the pocket. The apron is then placed on the patient with the lower edge resting on the thighs. The Pb component of the apron was tested by exposure to a beam of 90 kv at 20 ma-sec at a focus-film distance of 26 in. Exposure of the dosimeter to the direct beam without protection from the Pb gave a reading of 140 Mr; with the Pb between the source and the dosimeter the radiation received by the latter was unregistrable. The gonadal dose received by the patient wearing the apron is negligible. (P.C.H.)

**10874** ACUTE RADIATION DEATH RESULTING FROM AN ACCIDENTAL NUCLEAR CRITICAL EXCURSION. IX. SUMMARY. Thomas L. Shipman (Los Alamos Scientific Lab., N. Mex.). J. Occupational Med., 3: 191-2(Mar. 1961).

Major facts of a nuclear criticality accident, which resulted in the death of 1 man (K) and substantial exposures to 2 others, are recapitulated. The critical excursion took place in a tank of solution from which Pu was being recovered, and the number of fissions was calculated to be $\sim 1.5 \times 10^{17}$. The average whole-body dose to K was estimated to be between 3900 and 4900 rads, with the incident dose to the upper abdomen calculated to be ~12000 rads, neutrons plus gamma. Two other workers, neither of whom showed any signs or symptoms of injury other than alterations in their blood counts, received total doses of approximately 130 and 35 rads, respectively, most of this being gamma radiation. K went promptly into shock and was unconscious within a few minutes of the accident. He was brought out of shock, but died 35 hr after the accident. Marked changes were observed in the hemopoietic and urinary systems, heart, gastrointestinal tract, and bone marrow. Lymphocytes were not found in the circulating blood after the eighth hour, and there was virtually complete urinary shut-down despite administration of large amounts of fluids. A surprisingly large percentage of the material was recovered from the pulmonary lymph nodes. K's dose varied widely in different parts of the body and even in different parts of the same organ, such as the heart and stomach. From data on the other 2, it appears that the changes following exposures in excess of 100 rads are characteristic and of clinical significance, whereas doses below 50 rads produce blood changes too slight to be of any diagnostic value. (P.C.H.)

**10875** SAFETY IN X RAYS? Harris Jackson. Lancet, 2: 432-3(Aug. 19, 1961).

Previous pessimistic reports on the harmful effects of antenatal diagnostic radiation are criticized. After a reevaluation of the data of several widely quoted surveys, particularly relating to the increased incidence of leukemia in children irradiated in utero, it was concluded that: there is no evidence that diagnostic antenatal irradiation doubles or otherwise increases the risk of childhood malignancy; if there is a risk (in spite of the lack of evidence thereof) it could not be detected in surveys of 64000 pelvimetries; as the fetus is considered to be at the most sensitive stage of life, the absence of a demonstrable risk from the relatively large whole-body doses in pelvimetries precludes any measurable risk from ordinary doses after birth; and as diagnostic doses today are far less than those used at the time the survey children were exposed, the undetectable risk, if there is a risk, is correspondingly reduced. (H.H.D.)

**10876** MEDICAL PROCEDURES FOR RADIATION ACCIDENTS. Med. J. Australia, 1: 256-8(Feb. 17, 1962).

An outline of recommended steps to be taken in event of contamination accidents is given. The sequence of measures to be carried out are: determine whether radioactive contamination is present, taking necessary precautions such as wearing protective clothing; remove the contaminated or exposed person to a safe area without entering the radiation field, if possible; keep all nonessential persons away to avoid spread of the contaminants; give first aid immediately but do not attend to minor injuries before decontamination; collect all available evidence on the extent and nature of contamination or external exposure; decontaminate the subject as far as possible before removal to hospital or other medical station where major injuries may require further decontamination; save all clothing, dressings, blood, vomitus, and excreta for subsequent analysis; attempt to alleviate psychologic trauma of the subject by sedation and reassurance, before admission to hospital. A stepwise procedure for decontamination of the subject is also described. In most cases decontamination is best carried out by the subject himself. Various kinds of radiation exposure are discussed as well as the immediate and long-term harmful effects. (H.H.D.)

**10877** THE ORNL MOBILE RADIATION MEASUREMENT LABORATORY. T. V. Blosser and R. M. Freestone, Jr. (Oak Ridge National Lab., Tenn.). Nucleonics, 21: No. 2, 56(Feb. 1963).

This mobile radiation shielding laboratory is the equal of many stationary facilities in capabilities and versatility and is completely self-contained. The truck is an essentially unmodified Ford Vanette. Shock mounted equipment occupies most of the interior with a work-table area forward of the driver's seat. Beneath one of the racks is a lead-shielded scintillation counter. An air conditioning system ensured that all racks are cooled. Neutron and gamma detectors are interchangeably connected to the counting equipment by 250-ft coaxial cables. Three types of instruments cover a wide range of gamma-ray intensities. Water-

tight aluminum housings and plastic-sheathed cable permits using the radiation-sensing instruments in water. Sound-powered telephones maintain continuous communications between operators recording data and controlling the detector head. A number of standardized sources are carried for calibration. (C.E.S.)

**10878** THE DOSE DISTRIBUTION IN THE USE OF AN OBLIQUE TUBE. Gundolf Beier and Hermann Kuenlen (Städt. Krankenhauses Munich). Strahlentherapie, 119: 540-4(Dec. 1962). (In German)

In cases, in which irradiation has to be done oblique to the surface, the use of an oblique tube was found suitable, especially for sieve irradiation. The dose conditions obtained with a 14°-oblique tube were investigated. The results show, that dose compensation by wedge-filter or gradual sieve is unprofitable. For dose calculation the tables by Grebe and Wiebe, and Schröck-Vietor, respectively, can be used. (auth)

**10879** O PRAKTICHESKIKH VOPROSKH DOZIMETRII IONIZIRUYUSHCHIKH IZLUCHENII. (On Practical Problems in Ionizing Radiation Dosimetry). P. N. Kodochigov. Moscow, Publishing House of the Academy of Sciences, 1962. 136p.

Permissible doses and radiation effects on human organisms from external and internal exposures are discussed. Calculation methods for shielding and protection from radiation fluxes are analyzed. The book is designed for technicians and personnel handling radioisotopes. (R.V.J.)

# INDUSTRIAL APPLICATIONS OF ISOTOPES AND RADIATIONS

**10880** (ARF-1164-27) RESEARCH ON NEUTRON INTERACTIONS IN MATTER AS RELATED TO IMAGE FORMATION. Final Report. H. V. Watts (Illinois Inst. of Tech., Chicago. Armour Research Foundation). Aug. 22, 1962. Contract AT(11-1)-578. 96p.

Results of a study devoted to image formation by thermal or slow neutron energy beams are reported, in which the differences in the total neutron absorption coefficients between elements are large and vary randomly with atomic numbers, but in which neutron scattering constitutes a major part of the total absorption coefficient for many elements. The general applicability of neutron imaging is discussed along with imaging detectors, neutron sources, and image degradation. (J.R.D.)

**10881** (AEC-tr-5581) MEASUREMENT OF THE CONCENTRATION OF PULVERIZED COAL IN PNEUMATIC CONVEYORS BY BETA TRANSMISSION. Hiroshi Imamura, Junro Tsujii (Tsuji), and Makoto Yokooji (Yokoogi). Translated from Radioisotopes (Tokyo), 11: No. 1, 16-22(1962). 26p. (Includes original, 7p.).

The experimental results with laboratory equipment showed that the instantaneous concentration of pulverized coal can be determined by measuring the intensity of beta rays penetrating through the pulverized coal in flowing stream. The equipment was designed to circulate the pulverized coal, and the concentration in a vertical straight pipe (290 mm in inside diameter) can be changed continuously over a difinite range by controlling the feeding rate of the coal to the pipe. Six measuring points were composed of two windows facing each other on the pipe wall, and windows were sealed with nylon films of 0.2 mm in thickness. Nylon film was favorable to the window on account of less absorption for beta rays and strong resistance for wear. The flow state of the pulverized coal at each measuring point was observed by measuring the intensity of penetrated radiations under the constant feed rate of pulverized coal. The concentration of the pulverized coal was varied over the range 0.2 to 1.2 or 1.4 kg per cubic meter of air with air speed of 12 to 14 m/sec, and the corresponding intensity of penetrated radiations was observed at a measuring point in fairly stable flow. Relative errors of the concentration caused by statistical fluctuation (estimated as twice of standard deviation) were calculated from the regressions of the radiation intensity upon the concentration. In these experiments, $Kr^{85}$ (25 mc), $Tl^{204}$ (20 mc), halogen-quenched G–M tube, and ionization chamber were employed. The relative errors of the concentration at 1.0 kg/$m^3$ were as follows: (1) $Kr^{85}$, ±2.8% for ionization chamber, ±4.0% for G–M tube. (2) $Tl^{204}$, ±3.2% for ionization chamber, ±5.0% for G–M tube. (auth)

**10882** THE APPLICATION OF RADIOISOTOPES IN THE FOOD INDUSTRY AND FOOD RESEARCH. László Guczi and István Kiss. Elelm. Ipar, 16: 240-3(Aug. 1962). (In Hungarian)

Methods based on the application of radioactive indicators and reagents, dilution and activation analyses, radiochromatography, and the absorption and reflection of radiation are discussed. The possibilities of applying radioisotopes in microbiology; for technical and technological processes, such as the measurement of density and concentration; and in process control, such as ventilation, corrosion, and examination of packaging materials are reviewed. (OID)

**10883** THE EFFECT OF LOW TEMPERATURES ON THE INACTIVATION BY IONIZING RADIATIONS OF CLOSTRIDIUM BOTULINUM SPORES IN MEAT. M. Ingram and Margaret J. Thornley (Low Temperature Research Station, Cambridge, Eng.). J. Appl. Bacteriol., 24: 94-104(Apr. 1961).

The effect of temperature on the inactivation of the spores was studied in minced pork meat irradiated by 2-Mev electrons and gamma rays. When electrons were used, differences in survival after 1 Mrad at 18, 0, and –75° were small and significant only when temperatures of 0 and 18° were compared, a slightly higher survival being obtained at 0°. The effects at 0° and –75° were further compared, using a range of gamma ray doses, and regression lines were calculated for the inactivations. Sterilizing doses, those that would give a survivor level of $10^{-12}$, were calculated, together with their 95% confidence limits. It was confirmed that the relation between the logarithm of the survival of irradiated spores and dose becomes linear only at doses above about 1 Mrad, whereas at lower doses the exponent increases with dose. It was concluded that low temperature has little effect on the sterilizing dose of ionizing radiations. (H.H.D.)

**10884** RADIOISOTOPIC METHOD OF EVALUATING DISPERSED SYSTEMS. I. EMULSIONS. James B. Appino, John E. Christian, and Gilbert S. Banker. (Armour Pharmaceutical Co., Kankakee, Ill.). J. Pharm. Sci., 51: 254-7 (Mar. 1962).

A new method was developed for determining the phase uniformity of emulsions and for detecting and expressing ratios of creaming of emulsions that is applicable to water/oil and oil/water emulsions with either phase being labeled. The methods used to prepare emulsion samples were: $NaI^{131}$ was added to the water phase of the finished emulsion; $I^{131}$-iodobenzene was either added to the oil before emulsification; or incorporated in liquid petrolatum, Span 20, and Tween 20 and added to the emulsion. The radioactivity added to the emulsions had no effect on the particle size or viscosity of the emulsions. For the emulsion system studied, much less time was required for the radioisotopic evaluation than for visual or microscopic evaluations, and great sensitivity was shown by the detection of phase separation before it became visible. Advantages of the radioisotopic method of evaluation are given. If a beta emitter such as $P^{32}$ were used to label the water phase, the sensitivity would be increased due to the greater absorption of the beta particles as the emulsion tended to cream. (P.C.H.)

**10885** THE MEASUREMENT OF WATER FLOW WITH RADIOISOTOPES. [PART] I. Franz Walter Baehr. Wasserwirtschaft, 52: 173-7(July 1962). (In German)

The measuring of flow velocities of water in open channels and underground with the help of radioisotopes is surveyed. Investigations were made on the applicability of radioisotopes in measuring the flow of winding river sections, such as Loisach and Isar in Bavaria, in order to make provisions against flood damage. At a certain moment, 9

mc of $I^{131}$ in the form of NaI were dispersed over the entire river width, and 3 hr later 30 km downstream 61 water samples were collected every 5 min for 5 hr. The $I^{131}$ was precipitated, filtered, and the activity measured with a $\beta$-counter. The maximum activity was reached 5 hr and 6 min after injection, from which a mean flow velocity of 25 cu m/sec was calculated. (OID)

**10886** THE MEASUREMENT OF WATER FLOW WITH RADIOISOTOPES. [PART] 2. Franz Walter Baehr. Wasserwirtschaft, 52: 222-6(Aug. 1962). (In German)

In measuring open-channel flow, absolute values of flow velocity were made, while in measuring groundwater flow, only the relative values, e.g., the falling off of the concentration, were of interest. For this purpose, a well having an inner diameter of 50 to 100 mm, was dug to such a depth that it penetrated the entire groundwater zone. The water was injected with 0.01 mC of an $I^{131}$ solution. Subsequently, a $\beta$-counter was dropped down, and the pulses/min were measured. The activity decline indicated the velocity of groundwater movement. Radioisotopes were established as an essential tool in hydrology. (P.C.H.)

**10887** MEASUREMENT AND CONTROL IN THE SUGAR INDUSTRY BY MEANS OF ISOTOPES. Alfons Schlect. Zucker, 15: 374-80(July 1962). (In German)

Actual and potential uses of radioisotopes in the beet sugar industry are reviewed. Several fundamental facts concerning radiation and radioisotopes are given, and the application of radioisotopes in sugar beet extraction and sugar refining is discussed. However, discussion is restricted to density determinations using $Cs^{137}$ as the radiation source and an ionization chamber for radiation measurement. The use of the well-known attenuation equation for $\gamma$ radiation to measure the density of the sugar solution and its sugar content is explained. The discussion includes the accuracy attainable, statistical variations in relation to measuring time, and instrument sensitivity and its adjustment to the required measurement range. Since the sugar industry deals with materials, which under high pressure and temperature are viscous, semi-solid, and sticky, no other measuring method offers the advantages obtained by using radioisotopes, which permit measurements to be carried out without contact with the measured material. (P.C.H.)

**10888** EFFEKTIVNOST PRIMENENIYA RADIOAKLIVNYKH IZOTOPOV V NARODNOM KHOZYAISTVE. (Efficiency of Radioisotope Applications in National Economy). G. F. Mikheev and V. I. Postnikov. Moscow, Gosatomizdat, 1962. 104p.

A general survey is given of the results and efficiency in radioisotope applications in USSR. Applications of radioisotopes and nuclear radiation in prospecting and exploration of natural resources, metallurgical processes, construction, food industry, and various light industry processes are discussed. (R.V.J.)

# INSTRUMENTS AND INSTRUMENTATION

## General and Miscellaneous

*Refer also to abstract 10856.*

**10889** (AD-252467) SOVIET NUCLEAR INSTRUMENTATION AND CONTROL FOR PROPULSION. Report No. 2. (Library of Congress. Air Information Div., Washington, D. C.). Feb. 1, 1961. 14p. (AID-Report-61-10).

Development of selected items of instrumentation and control for nuclear propulsion are described. Included are discussion and information concerning a method of collimating recoil protons. The use of a differential ionization chamber as a gamma indicator, reduction of errors in radiation flux measurements, design of a fluid amplifier, and design of a membrane-type pneumatic actuator. (J.R.D.)

**10890** (ANL-6634) TUNNEL DIODE CIRCUIT ANALYSIS. Ronald G. Roddick (Argonne National Lab., Ill.). Oct. 1962. Contract [W-31-109-eng-38]. 50p.

Graphical and graphico-analytic methods were applied to the most common tunnel diode circuit configurations. The isocline method and a useful generalization of the Lienard Method were developed and applied, solutions and stability criteria were obtained by singular point analysis, and methods using linearized characteristics or simple graphical operations were applied. (auth)

**10891** (ANL-FGF-339) A FILM COPYING TECHNIQUE FOR IMPROVING RADIOGRAPHIC CONTRAST. N. S. Beyer, Harold Berger, N. P. Lapinski, and I. R. Kraska (Argonne National Lab., Ill.). Apr. 1962. Contract [W-31-109-eng-38]. 10p. (UAC-6372)

By copying radiographs on high gamma photographic film, a significant increase in overall system gamma can be obtained. For a given material of uniform density, a change in thickness will result in a change in x-ray transmission which in turn produces a change in the optical density of a radiograph. This change in density can be intensified by factors as high as 6 times by film copying techniques. A number of applications, in which this intensification has proved useful, are described. (auth)

**10892** (BNL-6437) LOW FREQUENCY AMPLIFIER IH-130-1. Jorge Llacer (Brookhaven National Lab., Upton, N. Y.). Oct. 23, 1961. Contract [AT-30-2-GEN-16]. 4p. (IHR-111)

The design of a transistorized d-c coupled amplifier having very good gain stability and low drift of the output d-c level is described. Low-frequency input signals from a low-impedance source are amplified by the system to an approximate peak-to-peak amplitude of 4 v. (J.R.D.)

**10893** (HW-75746) A DEVICE FOR RECORDING FUEL ELEMENT DIMENSIONS ON PUNCHED PAPER TAPE. G. E. Driver (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Dec. 1962. Contract AT(45-1)-1350. 35p.

A system for translating the position of a strip-chart recorder potentiometer shaft into decimal digital form is described. By means of a paper tape punch, measurements of fuel element dimensions are thereby recorded in a medium convenient for computer analysis. Speed and reliability of data handling are greatly increased compared with formerly used clerical methods. (auth)

**10894** (HW-SA-2616) X-RAY DIFFRACTION OF HIGHLY IRRADIATED FUEL ELEMENTS. [W. I. Clark]. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 28, 1962. Contract AT(45-1)-1350. 5p.

The analysis of such samples involves the considerations of protecting the operator from excess exposure and detecting and measuring the diffracted x-ray beam in the presence of high radioactivity backgrounds from samples. A diffraction unit is described in which provisions were made for shielding and beam differentiation. (J.R.D.)

**10895** (KFK-113) UNTERSUCHUNGEN ÜBER AUFLÖSUNGSVERMÖGEN UND RAUMWINKEL VON EINLINSIGEN TEILCHEN-SPEKTROMETERN. TEIL I. (Investigation of the Resolving Power and Solid Angle of Single-Lens Particle Spectrometers. Part I). S. Galster and G. Hartwig (Kernforschungszentrum. Institut für Experimentelle Kernphysik, Karlsruhe, Germany and Kernreaktor Bau- und Betriebs-Gesellschaft m.b.H., Karlsruhe, Germany). Sept. 1962. 43p.

An investigation was made to determine which spectrometer type and which geometric arrangement yielded the largest solid angle for a definite impulse resolving power [$(\Delta P/P) \approx 1\%$] for fixed magnet openings and vice versa. Only single-lens spectrometers were considered. Magnetic fields and particle trajectories, the solid angle, impulse resolving power, optimization of the magnetic parameters with reference to impulse resolution and the solid angle, and the counter length are discussed. (M.C.G.)

**10896** (LNF-62/107) A CRYSTAL METHOD FOR MEASURING THE LINEAR POLARIZATION OF PHOTONS IN THE MULTI-Gev REGION. Note No. 174. G. Barbellini, G. Bologna, G. Diambrini, and G. P. Murtas (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). Dec. 13, 1962. 11p.

A method for measuring linear polarization of photons based on asymmetry in pair production and taking into account the pair particles emitted at any angle in a thin crystal converter is proposed for energies of 1 Bev or more. The beam is permitted to fall on a thin diamond crystal in a pair spectrometer, and angular alignment information gives the necessary data. (D.C.W.)

**10897** (MATT-121) AN ION ENERGY ANALYZER FOR PLASMA MEASUREMENTS. H. P. Eubank and T. D. Wilkerson (Princeton Univ., N. J. Plasma Physics Lab.). May 1962. Contract AT(30-1)-1238. 34p.

Flux measurements on low-energy, neutral, and charged particles provide direct knowledge of plasma composition and energy distribution. A particle analyzer is described for the energy range between a few ev and several thousand ev which is sensitive to single ions and has an inherent time resolution of less than 50 millimicroseconds. Experimental results are given for both energy and mass analysis of positive ions ejected by a pulsed-arc plasma gun. Significant variations in composition and energy distributions are observed with variations in gun voltage. Preliminary results are presented on the detection of low-energy neutral particles. (auth)

**10898** (N62-10115) BASIC EXPERIMENTAL RESEARCH LEADING TO IMPROVED COLD ELECTRON SOURCES AND NEW TYPES OF VELOCITY FILTER MASS SPECTROMETERS. Semiannual Status Report, July 1, 1961 to December 31, 1961. M. K. Testerman (Arkansas. Univ., Little Rock. Graduate Inst. of Tech.). 46p.

A resistance-strip magnetic electron multiplier was constructed for use in secondary emission studies. Preliminary studies of thin-film bimetallic alloys revealed that tin oxide films exhibited long lifetime and high secondary emission coefficients to warrant their use in the resistance strip multiplier. A titanium oxide film was used as the field strip and a titanium-base tin oxide film as the dynode. The multiplier was incorporated into a triode ion gauge as an ion source. The multiplier output yielded an initial gain of 3500 which decreased uniformly to 400 after 14.5 hours of operation. The decrease in gain was caused by carbonaceous deposits which accumulated on the dynode owing to the use of an oil diffusion pump on the vacuum system. The deposits presumably would not occur in a clean vacuum system or in outer space. Design and construction of a Lissajous mass spectrometer have progressed through the electron and ion generation stages. An electron gun beam was used successfully as a source of ionizing electrons, and a cold electron source is being developed for inclusion in the tests. A focusable, highly collimated small-diameter ion beam was generated which can be electrostatically deflected by very low potentials. (auth)

**10899** (NP-12229) AMPLIFICADOR ELECTROMETRICO. INFORME NO. 70. (Electrometric Amplifier. Report No. 70). Carlos Marazzi and Santiago Pinasco (Argentina. Comisión Nacional de Energia Atómica, Buenos Aires). 1962. 12p.

An amplifier designed to measure small voltages applied to very high impedances is described. The amplifier consists of a three-stage d-c circuit without feedback; The first stage is an electronic valve and the second and third are cathode followers. The circuit is shown schematically and its characteristics are given. Its uses as amplifier, valve voltmeter, microampmeter, and meter for characteristics of nonlinear elements are discussed. (J.S.R.)

**10900** (NP-12363) DETECTION OF NUCLEAR RADIATION IN STATIC AND FLOWING LIQUID HYDROGEN. Quarterly Report No. 3, July 1, 1961–September 30, 1961. PART I. CRYOGENIC APPARATUS FOR A LIQUID HYDROGEN IONIZATION FLOW CHAMBER. J. C. Drobinski, Jr. PART II. POSSIBLE USE OF SEMICONDUCTORS AS NUCLEAR RADIATION DETECTORS AT LIQUID HYDROGEN TEMPERATURES. A. Thomas (Tracerlab, Inc., Waltham, Mass.). Contract NASr-20. 31p.

Work continued on establishing a cryogenic facility for handling liquid $H_2$. Also, a study of the possible use of semiconductors as nuclear radiation detectors at liquid $H_2$ temperatures was initiated. A conclusion of this study is that Ge is probably less susceptible to radiation damage from $Kr^{85}$ than Si. (J.R.D.)

**10901** (NP-12390) MEASUREMENT OF DENSITY BY BETA RAY ABSORPTION. Status Report. L. Svansson and R. Winckler (European Company for the Chemical Processing of Irradiated Fuels, Mol, Belgium). Dec. 8, 1960. 34p. (ETR-95)

Beta ray absorption was investigated as a means of measuring the density of uranium solutions with high accuracy. An ionization chamber instrument was used in measurements to test the accuracy and reliability of the method. The effects of temperature and possible sources of errors were studied. (D.L.C.)

**10902** (NYO-9676) STRATOSPHERIC MONITORING PROGRAM QUARTERLY PROGRESS REPORT, APRIL 1962–JULY 1962. M. Lippmann, comp. (Del Electronics Corp., Mount Vernon, N. Y.). Jan. 13, 1963. Contract AT(30-1)-2363. 59p.

Design work was completed and construction initiated on a prototype field altimeter based on the gas density dependence of Townsend discharge current in an electrical discharge. The design of an ion tracer air velocity meter for laboratory applications, and construction of three units were successfully completed. Theoretical and experimental support is presented, showing the applicability of the ion tracer system to the accurate measurement of linear gas velocity. The operating range of the laboratory meter is 150 to 2500 ft/min at ambient pressures between 200 $\mu$ and 30.0 mm Hg. Further investigations on the application of the ion tracer concept to flowrate measurements are presented. By generating velocity profile curves with an ion tracer calibrated thermoanemometer, it was possible to determine the flowrate for 2 flow and pressure conditions; 37.5 cfm at 19.6 mm and 75 cfm at 9.8 mm Hg. Comparison with a calibrated Rotameter technique was within 5% in both cases. Also presented are some preliminary investigations leading to the development of a generalized ion tracer flowmeter for low gas densities. Results of some supplemental electrical discharge experiments in rarefied atmospheres are described. It was observed that electrical oscillations could be produced in a low density gas discharge, and could serve as the basis of a small, light and convenient altimeter design. An attempt to generate ion winds at stratospheric pressures was made with an experimental configuration which is described. No measurable velocities could be observed and this configuration was abandoned. Flowrate calibration data and curves based on 1) PR-2 flowmeter and 2) integrated ion tracer velocity profiles, as functions of fan speed, are presented for the Model I precipitator sampler. The tests were conducted at simulated altitudes corresponding to 5 and 10 mm Hg for flowrates between approx. 50 and 150 cfm. (auth)

**10903** (ORNL-TM-344) SOME ELECTRONIC ACCOUNTING DEVICES FOR DATA LOGGING APPLICATIONS. S. H. Jury (Oak Ridge National Lab., Tenn.). Jan. 31, 1963. Contract [W-7405-eng-26]. 47p.

Several analog accounting circuits were designed to determine their applicability to pulse counting in connection with metering of flows in waste calcination processes. Results indicate that a one amplifier design based on transfer function simulation is to be recommended. By use of this circuit design, frequencies of 200 to 50,000 cps can be counted. (J.R.D.)

**10904** (SCTM-100-62-81) CHARACTERISTICS OF THE LINEAR VARIABLE DIFFERENTIAL TRANSFORMER GAGE HEAD. C. Furnberg (Sandia Corp., Albuquerque, N. Mex.). Dec. 1962. Contract AT(29-1)-789. 21p.

The important electrical and mechanical characteristics of linear variable differential transformer gage heads are defined, and a standard method and format for specifying these characteristics is proposed. Linearity data for d-c displacement transducers are included. (auth)

**10905** (SCTM-230-62(14)) AN EMPIRICAL DESIGN FOR HIGH-VOLTAGE PULSE RESISTORS. Richard Lee Davis (Sandia Corp., Albuquerque, N. Mex.). Nov. 1962. Contract [AT(29-1)-789]. 19p.

The construction and operation of wirewound, noninductive resistors having time constants of $10^{-7}$ to $10^{-9}$ seconds are described. Some units were operated up to 600 kv with a pulse width less than 0.2 $\mu$sec. Failures at 600 kv have a repeatable mode. Formulas are given for winding the resistors, and the steps of construction are also detailed. Improvements are proposed for operation at higher peak voltages. (auth)

**10906** (TID-15312) A SELF-BIASED, HIGH REPETITION RATE BLOCKING OSCILLATOR. Edward E. Godin (Sandia Corp., Albuquerque, N. Mex.). [Jan. 20, 1961]. Contract [AT(29-1)-789]. 3p. (SCDC-2223X)

A circuit is described for self-biasing the output tube of a monostable blocking oscillator. In the circuit, a dual zener diode provides the bias voltage and also a low-impedance discharge path for the coupling capacitor. Thus, in operation at high pulse repetition rates up to 50 kc, the bias is not increased sufficiently to shut off the oscillator. (D.L.C.)

**10907** (TID-15860) DESIGN AND DEVELOPMENT OF HIGH VOLTAGE DIVIDERS FOR IMAGE INTENSIFIER TUBES. Thomas W. Hoffer (Argonne National Lab., Ill.). Apr. 1962. Contract [W-31-109-eng-38]. 15p. (UAC-6350)

Safety, reliability, and corona reduction were the considerations in designing these dividers for 60-kv image intensifier tubes. The development and construction details are described for corona-free dividers with adjustable lens voltages that give an excellent degree of protection to the operator against high voltage. These units were constructed with ordinary tools and materials found in most laboratories. (auth)

**10908** (TID-15865) SIMULTANEOUS MEASUREMENT OF TWO ION CURRENTS BY PULSE COUNTING IN A MASS SPECTROMETER. Leonard A. Dietz (Knolls Atomic Power Lab., Schenectady, N. Y.). [May 1962]. Contract W-31-109-eng-52. 20p.

Simultaneous measurement by pulse counting two ion beams with a mass separation of $\Delta M/M$ as small as $1/250$ was accomplished in a 30-in.-radius double-focusing mass spectrometer of the Dempster type. Positively charged ions are produced by thermal ionization on a hot filament and are detected by two heavily shielded electrostatic electron multipliers. The disadvantage of multiplier size is overcome by using electrostatic deflecting plates to increase the dispersion between two resolved beams by deflecting each beam in opposite directions from the focal plane of the magnet into its multiplier detector. (auth)

**10909** (TID-15951) A CASCADE MASS SPECTROMETER. F. A. White, J. C. Sheffield, and F. M. Rourke (Knolls Atomic Power Lab., Schenectady, N. Y.). Apr. 26, 1962. Contract W-31-109-Eng-52. 11p.

The design and applications of a cascade mass spectrometer are discussed. The electromagnet is basically "C" shaped, and two successive 180° trajectories can be accommodated within the pole face boundaries. Two source assemblies are provided: the first, a surface ionization source with focusing plates and, the second, located at the focal point of the first 180° spectrometer, can be used for several things. Experimental observations included assuming $E_2 > E_1$, $E_2 < E_1$, pulsed techniques, and sputtering phenomena. Three examples of the use of the mass spectrometer are given. (M.C.G.)

**10910** (TID-16209) A PULSED-MOLECULAR-BEAM MASS SPECTROMETER FOR STUDIES OF ATOMIC AND IONIC IMPACT PHENOMENA ON METAL SURFACES. Manfred Kaminsky (Argonne National Lab., Ill.). Apr. 1962. Contract [W-31-109-eng-38]. 18p. (UAC-6399)

The design features of a pulsed-molecular-beam mass spectrometer, which will allow a variety of direct measurements of certain atomic and ionic impact phenomena on metal surfaces in which measurements heretofore could be made only indirectly, are described. (auth)

**10911** (TID-16251) THIN FILMS FOR ACCURATE MEASUREMENT OF CHARGED-PARTICLE RANGES. T. L. Watts and C. J. Sneider (Yale Univ., New Haven). [July 5, 1962]. Contract [AT(30-1)-2726]. 7p.

A method is reported for making plastic film of thickness 100 to 400 $\mu g/cm^2$ and mounting it in thin Al rings 0.012 in. thick and $1\frac{3}{8}$ in. in dia. Foils mounted in such fashion are tough, may be repeatedly handled, arranged in stacks, and are made relatively quickly. The film was made by spraying a solution of the plastic on glass plate and, after drying, allowing it to float off in water. The tough foils were made from small $1\frac{1}{2}$ in. dia. films mounted between Al rings and clamped together in a set of progressive dies. About 5% of 100 foils made had a thickness variation of larger than ±5%. The mean foil thickness varied by less than $\pm 7\frac{1}{2}\%$ among the 100 foils. (auth)

**10912** (TID-16312) A 360° TANDEM MASS SPECTROMETER. F. A. White and J. C. Sheffield (Knolls Atomic Power Lab., Schenectady, N. Y.). [June 2, 1962]. Contract W-31-109-eng-52. 8p.

A small prototype of a 360° tandem mass spectrometer was built to see if the principle of a two-stage instrument could be applied to a very small radius of curvature magnet. A single magnet, suitably shimmed, was used to provide two 180° analyzing sectors. The entire trajectory of the ion beam was contained in the magnetic pole-face boundary. Performance of the instrument is discussed. (M.C.G.)

**10913** (TID-17740) THE PHANTOM GAGE (A COMBINED PART AND GAGE SPECIFICATION TECHNIQUE). Edward S. Roth (Sandia Corp., Albuquerque, N. Mex.). [Jan. 1963]. Contract [AT(29-1)-789]. 8p. (SCDC-3010)

A new dimensioning and tolerancing method is described which is pictorial and easy to use. The method specifies the acceptable part by defining the acceptance gage and part on one drawing. The method is illustrated for the optical chart and receiver types of phantom gages. (D.L.C.)

**10914** (TID-17744) A LIQUID HELIUM COOLED TILTING STAGE FOR AN ELECTRON MICROSCOPE. J. A. Venables (Illinois. Univ., Urbana). [1962]. Contract AT(11-1)-1198. 8p.

A low temperature tilting stage cooled by liquid helium has been built for the Hitachi electron microscope to permit observation of metal foils in transmission at low temperatures. The unit described has maintained temperatures of less than 15°K, permitting observations of specimens for an hour at a time without contamination. (D.C.W.)

**10915** (TID-17749) ELECTRICAL NOISE IN INSTRUMENTATION SYSTEMS. H. D. Arlowe (Sandia Corp., Albuquerque, N. Mex.). Dec. 1962. Contract AT(29-1)-789. 15p. (SCDC-2727)

A discussion is given of the causes and possible solutions to some noise problems in instrumentation systems. (auth)

**10916** (TID-17788) ANALOG-COMPUTER STUDY OF NOISE MEASUREMENT ERRORS. C. E. Cohn (Argonne National Lab., Ill.). Oct. 1, 1962. Contract [W-31-109-eng-38]. 7p. (RED-EPM-106)

A computer analysis of the performance of linear and square-law detectors for measurement of the mean square amplitude of narrow-band noise indicated that both types of detector would give the same statistical error for a given situation. (M.C.G.)

**10917** (UCRL-6832) A SUMMATION COUNTER FOR THE DETECTION OF WEAK SIGNALS. L. W. Ducote and

G. O. Brink (California. Univ., Livermore. Lawrence Radiation Lab.). Mar. 29, 1962. Contract W-7405-eng-48. 19p.

A summation counter is described which was developed to detect weak signals in the presence of a large background. A process of adding signal plus noise then subtracting noise produces an accumulation of net signal on the summation counter. The circuits associated with the pulse signal display and the gate switching necessary to add and subtract are discussed. A number of techniques to gate all the pulse display tubes were evaluated in an effort to find the most convenient method. Automatic sequencing and printout features are mentioned for possible use with the counter. (auth)

**10918** (UCRL-9035(Rev.)) CURRENT-SWITCHING CIRCUITRY. Jack Gilbert Salvador and D. O. Pederson (California. Univ., Berkeley. Lawrence Radiation Lab.). July 17, 1961. Contract W-7405-eng-48. 31p.

A group of high-speed switching circuits that use the basic current-switching mode of operation are discussed. A dynamic analysis of the basic current-switching mode is presented in which it is shown that this mode is really an overdriven amplifier in a common-emitter configuration. Therefore the dominant natural frequency, which determines the switching time, is actually $f_\beta$, the short-circuit cutoff frequency in the common-emitter configuration. The comparison of switching-time estimates and experimental measurements, considering only the gain-bandwidth product, often shows agreement within less than a factor of two. The reasons for this conformity are given and the errors introduced by considering the gain-bandwidth product alone are described. An analysis of the dynamic and steady-state current-switching flip-flop is also included in which it is shown that the natural frequency of the regenerative loop lies in the right-hand plane of the complex frequency plane, and is dominant during switching. A conventional saturated Eccles-Jordan circuit is compared analytically and experimentally with the current-switching flip-flop. Switching time, pulse pair resolution, and repetition rate describe each circuit's operation. (auth)

**10919** (USNRDL-TR-591) PHOTOMICROGRAPHIC TECHNIQUE FOR MEASURING GRAIN DENSITIES OF HIGHLY IONIZED PARTICLE TRACKS IN NUCLEAR EMULSIONS. E. V. Benton (Naval Radiological Defense Lab., San Francisco). Oct. 26, 1962. 21p.

A technique for rapid and accurate measurement of gap lengths of nearly saturated particle tracks in nuclear emulsions is reported. The method consists of obtaining photomicrographs of particle tracks with a superimposed image of a calibrated eyepiece-micrometer disc. The gap lengths were measured to an accuracy of $\frac{1}{4}$ micron. (auth)

**10920** (WAPD-T-1447) THE SHIPPINGPORT DATA ACQUISITION SYSTEM. R. T. Dressler (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). Jan. 1962. Contract AT(11-1)-Gen-14. 17p.

The needs and requirements for an automatic Data Acquisition System for the Shippingport Plant are discussed, and the design of the Data Acquisition System that was installed is described. The Daystrom Automatic Data Logging and Computing System is described in detail. (auth)

**10921** (SCL-T-460) REVIEW OF THE CIRCUITS OF TWO-CONDITION, FLIP-FLOP STAGES WITH COMPLEMENTARY TRANSISTORS. F. Schreiber. Translated by Marcel I. Weinreich (Sandia Corp., Albuquerque, N. Mex.) from Frequenz, 16: 121-5(Apr. 1962). 14p.

The numerous flip-flop stages with two complementary transistors that are known can be derived from three simple fundamental circuits which satisfy a rule of symmetry as well as two rules for sustaining the static operating conditions. Two of the fundamental circuits with parallel and series connection, respectively, of the transistor circuits are characterized jointly by the fact that the two emitters are separated by a high potential difference; the third fundamental circuit has likewise series character, but the emitters are at the same potential. For a presentation of bistable double-current gates of symmetrical layout, the basic circuits can be composed in pairs. Some circuit variants are devised which are of interest for the realization of complementary flip-flop stages. (auth)

**10922** PORTABLE DOP TESTER FOR INSPECTION OF HIGH-EFFICIENCY FILTERS. C. L. Lindeken, K. F. Petrock, E. L. Beard, and J. L. Murrow (Univ. of California, Livermore). Am. Ind. Hyg. Assoc. J., 23: 473-9 (Nov.-Dec. 1962).

Description is given of a portable filter tester consisting of a di-octyl phthalate (DOP) aerosol generator and light-scattering photometer, which is used to detect damage or imperfections in high-efficiency filters. Testing consisted of introducing the DOP aerosol at the upstream side of the filter while sampling downstream for penetration of DOP through the filter using the photometer. The tester is used routinely to inspect new filters prior to issue. A system of scanning probes is described for use with cartridge filters. They permit sampling close to the point of DOP penetration before dilution of the aerosol with filtered air and result in a much more sensitive method for detection of holes in the filter. When the probes are used in the manner described, a single hole $\frac{1}{16}$ in. in diameter is clearly detectable, whereas this size hole usually cannot be seen using a centerline probe sampling at a point where the penetrating DOP is well mixed with the air flow. (P.C.H.)

**10923** THE ELECTROMAGNETIC ISOTOPE SEPARATOR OF THE SGAE IN THE SEIBERSDORF REACTOR CENTER. F. P. Viehboeck and F. Buschbeck (Osterreichische Studiengesellschaft fur Atomenergie, Vienna). Atomkernenergie, 7: 362-8(Oct. 1962). (In German)

The electromagnetic isotope separator of the SGAE uses an inhomogeneous magnetic sector field as a mass analyzing field. Two-directional focusing and double dispersion as compared with a homogeneous field is reached by a proper choice of the field parameters. The magnet and the stabilized current supply is described. Magnet current is constant to $1:5 \times 10^{-5}$. The stability of the acceleration voltage is $1:1 \times 10^{-4}$. An automatic rough regulation and an electronic fine control system is used. In addition a beam radius stabilizer was developed. The vacuum system consists of two movable pumping units with one diffusion pump each. Finally the first results are presented. (auth)

**10924** IMPROVING PULSE RISE TIME WITH SNAP-OFF DIODES. K. C. Hu (RCA Labs., Princeton, N. J.). Electronics, 36: No. 7, 68-70(Feb. 15, 1963).

Tenfold improvement in pulse rise time was provided by cascading charge-storage diodes. Snap-off effect of the cascaded diodes was also used to generate ultrashort pulses for oscilloscope sampling. The recurrence rate of the snap-off action was as high as several hundred megacycles. The experimental results indicated that charge-storage diodes can be used more widely either in fast-rise pulse generation or in short pulse generation for sampling or similar purposes. Some of the advantages of using charge-storage diodes were the relatively low cost and circuit simplicity. (C.E.S.)

**10925** SURFACE MOISTURE MEASUREMENT BY THE NEUTRON METHOD. V. Schuricht (Technische Hoschule, Dresden). Isotopen Tech., 2: 296-9(Oct. 1962). (In German)

Investigations on the dimension of moisture meters, which consist of $BF_3$ counters and Po–Be neutron sources, were carried out. The meters are so constructed that neutron detector and source are arranged directly next to each other and both touch the material to be measured as much as possible. The reflector should enclose the detector and source and consist of iron of approximately 2-cm thickness. (tr-auth)

**10926** THIN LAYER CHROMATOGRAPHY APPARATUS. Elizabeth Hansbury, D. G. Ott, and J. D. Perrings (Los Alamos Scientific Lab., N. Mex.). J. Chem. Education, 40: 31(Jan. 1963). (LADC-5405)

A simple and inexpensive apparatus for thin layer chromatrography was developed. It can be assembled from commonly available laboratory glassware and chemicals and obviates the applicators and supporting templates usually used. The apparatus consists of glass plates cut into two convenient sizes: 20 × 20 and 5 × 20 cm (which are grooved in order to contain the adsorbent layer), a glass developing chamber large enough to accommodate the larger plates, and a 1-l graduated cylinder cut off at the 600-ml mark that serves as a developing chamber for the smaller plates. (P.C.H.)

**10927** A NEW TYPE OF PARALLEL CRYOTRON. J. F. Marchand (Philips Research Labs., Eindhoven, Netherlands). Phys. Letters, 2: 57-8(Aug. 15, 1962). (In English)

Design and performance data are presented for a cryotron consisting of two parallel strips of Sn, lying in the same plane and simultaneously deposited on the surface of a glass substrate. Experimental curves are shown for the resistive behavior of the gate, the gain as a function of reduced temperature, and the gain characteristic in terms of reduced gate and control currents. (H.D.R.)

**10928** OPTICAL MEASUREMENTS ON MEAN ENERGY IONS ACCELERATED IN ELECTROSTATIC GENERATOR. V. M. Morozov. Pribory i Tekhn. Eksperim., No. 5, 33-4 (Sept.-Oct. 1962). (In Russian)

A method is given for measuring accelerated mean-energy ions by means of the optical wave produced. The method was also used for increasing the efficiency of a static generator as a high-stability source for accelerated particles. (tr-auth)

**10929** ELECTRON PARAMAGNETIC RESONANCE SPECTROMETERS. (Review). A. G. Semenov (Inst. of Chemical Kinetics and Combustion, Academy of Sciences, Siberian SSR). Pribory i Tekhn. Eksperim., No. 5, 5-18 (Sept.-Oct. 1962). (In Russian)

The general design and construction of various electron paramagnetic resonance radiospectrometers are reviewed. A direct serial detector RE 1301 and superheterogeneous spinning induction recording spectrometers are described. (R.V.J.)

**10930** EIGHT-LITER HYDROGEN–DEUTERIUM BUBBLE CHAMBER IN MAGNETIC FIELD. T. D. Blokhintsev, A. T. Vasilenko, V. G. Grebinnik, V. A. Zhukov, G. Libman, L. L. Nemenov, G. I. Selivanov, and Jung-Fang Yuan (Joint Inst. for Nuclear Research, Dubna, USSR). Pribory i Tekhn. Eksperim., No. 5, 51-9(Sept.-Oct. 1962). (In Russian)

Descriptions are given of the design and performance of an 8-liter hydrogen-deuterium bubble chamber with glass-metal construction and vertically distributed operational area. The effective magnetic field is 12 k gauss; dead time does not exceed 2 sec. (R.V.J.)

**10931** MILLIMETER RANGE RADIOSPECTROSCOPE WITH MAGNETIC FIELD SOURCE. G. M. Zverev, I. B. Krynetskii, D. M. Litvak, P. V. Chernov, and A. K. Shevchenko (Moscow State Univ.). Pribory i Tekhn. Eksperim., No. 5, 132-4(Sept.-Oct. 1962). (In Russian)

Descriptions are given of a radiospectroscope for paramagnetic resonance up to 100 Hertz. The small selenoid is supplied by a condenser. The device is capable of performing at liquid nitrogen and helium temperatures. (R.V.J.)

**10932** HIGH-RESOLVING POWER MASS SPECTROMETER WITH TWO-STAGE ION SEPARATION. B. A. Mamyrin and B. N. Shustrov (Inst. of Physics and Tech., Academy of Sciences, USSR). Pribory i Tekhn. Eksperim., No. 5, 135-41(Sept.-Oct. 1962). (In Russian)

A two-stage mass spectrometer with resolving power of $R_{50\%} \simeq 300$ and compensating resolving power of <10000 is described. The high resolving power and clear peaks permit satisfactory analyses of doublets. The over-all dimensions of analyzer and the total ion path in both stages are relatively small. (R.V.J.)

**10933** AUTOMATIC SCANNING OF MASS SPECTROMETER MAGNETIC FIELD. I. V. Goldenfeld and I. Z. Korostyshevskii (Inst. of Physical Chemistry, Academy of Sciences, Ukrainian SSR). Pribory i Tekhn. Eksperim., No. 5, 141-3(Sept.-Oct. 1962). (In Russian)

Descriptions are given of a single-tube scheme for automatic multi-speed magnetic scanning of mass spectra. The scheme exhibits strong current stabilization in the electromagnet at each established scanning process. (R.V.J.)

**10934** INSTALLATION FOR COMPRESSING He-3 INTO COUNTERS. N. P. Glazkov and V. F. Lyubchenko. Pribory i Tekhn. Eksperim., No. 5, 192-3(Sept.-Oct. 1962). (In Russian)

A mercury compressor used for purifying $He^3$ and compressing it into an ionization chamber or gas spectrometer is described. The efficiency of the device was tested on a 30 $cm^3$ ionization chamber at 5 atm. The chamber was tested using thermal neutron pulses, and a 100% recording efficiency is indicated. (R.V.J.)

**10935** PARAMETER OF THE MAGNETIC FIELDS USED BY WEAK- AND STRONG FOCUSING NUCLEAR INSTRUMENTS. C. C. Iliescu (Inst. for Nuclear Physics, Bucharest). Rev. Phys., Acad. Rep. Populaire Roumaine, 7: 389-96(1962). (In English)

Expressions are derived for the parameters of focusing magnetic fields, namely the scalar and vector magnetic potentials and the magnetic induction. These expressions are valid throughout the magnet gap and are independent of the strong- or weak-focusing character of the field. The fields considered are of the form $B_{\underline{z}} = \text{const} \times \underline{r}^{-\underline{n}}$, where $B_{\underline{z}}$ is the axial component of the magnetic induction in the median plane of the gap, $\underline{r}$ is the radial distance from the magnet axis in the median plane, and $\underline{n}$ is the "index" of the field. The expressions obtained can be used in analyses of particle orbits and pole-face shapes. (T.F.H.)

**10936** A NEW APPROACH TO THE THEORY OF LOW-FREQUENCY NOISE IN SEMICONDUCTORS. Petru Khandel. Rev. Phys., Acad. Rep. Populaire Roumaine, 7: 407-17(1962). (In Russian)

Various postulations are made on the mechanism of fluctuations generating low-frequency noises in semiconductors, a series of peculiarities in charge carrier motion divulged anticipated low-frequency fluctuations in

conductivity that are capable of generating the 1/f noise. (R.V.J.)

**10937** DESIGN OF A NEUTRON MONOCHROMATOR CONSISTING OF SEVERAL DISKS WITH A LONGITUDINAL AXIS OF ROTATION. V. P. Vertebni and V. V. Koloti. Ukr. Fiz. Zh., 7: 975-9(Sept. 1962). (In Ukrainian)

It is shown that a mechanical neutron monochromator may be made of several disks. The number of slits is limited, but this consideration is not of practical importance. (auth)

**10938** NEUTRON PULSE FORM AND TRANSMISSION FUNCTION OF TWO-ROTOR NEUTRON CHOPPER. I. THE NEUTRON CHOPPER WITH FLAT SLITS. V. P. Vertebni and V. V. Koloti. Ukr. Fiz. Zh., 7: 980-91(Sept. 1962). (In Ukrainian)

A method is described for calculating the neutron pulse and the transmission function of a two-rotor neutron chopper. Transmission-function formulas are presented for cases of different distances between the rotor and different angular phase shifts. (auth)

**10939** A MODIFIED WIEN FILTER AS ELECTRON MONOCHROMATOR. Werner Legler (Universität, Hamburg). Z. Physik, 171: 424-35(1963). (In German)

A velocity selector of the Wien type (crossed uniform electric and magnetic fields) was given the property of stigmatic focusing by replacing the uniform electric field by a field with cylindrical curvature. Focusing conditions, energy dispersion, and the apertural error were calculated. A monochromator of this type was constructed for electrons of 100 ev energy. With an exit aperture of 50 $\mu$ diameter an energy spread of 0.06 ev was measured. (auth)

**10940** A THERMOCOUPLE TYPE DETECTOR FOR IN-CORE POWER MONITORING TO 1800°F. R. A. DuBridge (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). IAEA Preprint No. SM-36/67. 9p. TID-17524

To be published in IAEA Proceedings of the Symposium on Neutron Detection, Dosimetry and Standardization, held in U.K.A.E.A. Harwell. December 10-14, 1962.

A thermocouple type detector was designed, fabricated and bench-tested for in-core power monitoring to temperatures of 1800°F and can probably be extended to higher temperatures. A high-temperature metal (e.g., zirconium) was alloyed with uranium and drawn into wire. This wire was inserted in the center hole of a metallic center-piece and a thermocouple was spot-welded to the center-piece, to measure its temperature. Two spacers separated the center-piece from the cable and the bottom-end plug so that heat was transferred almost entirely in the radial direction. The assembly was then welded together, evacuated and backed out at 1800°F, backfilled with the appropriate gas, and welded shut. The entire assembly was one quarter of an inch in diameter. The temperature difference between a uranium and non-uranium containing assembly is given by the following equation:

$$\Delta T = \frac{Q_{fission}}{2\pi L}\left[\frac{1}{2K_U} + \frac{\log (X_C/X_{C'})}{K_C} + \frac{(1/h_C) + (1/h_F)}{r_C}\right]$$

By choosing 304 stainless steel, $K_C$ is almost constant with respect to temperature and integrated neutron exposure. The detectors must be placed in environments such that $h_F$ and $h_C$ are constant, contribute a negligible amount to $\Delta T$, or contribute the same proportion of the temperature drop to $\Delta T$. By choice of alumel versus chromel thermocouple, the emf difference between the uranium and non-uranium containing assemblies is proportional to $\Delta T$ and almost constant with respect to integrated neutron exposure. Drift rates of the thermocouple elements at 1800°F are less than $U^{235}$ burnup rate. Detector readings can be related to local absolute power. By placing the detectors at the same point in each monitoring volume throughout the reactor and analytically correcting for any fuel or moderator differences throughout the reactor, the detector readings will be proportional to local power. The ratio of the reading of any one detector to the sum of the readings of the detectors will equal to the absolute power in that monitoring volume over the total power output of the reactor. Hence, absolute power is given by $P_{i\ Absolute} = R_i\ (P_{Total\ Absolute} / \Sigma R_i)$. (auth)

**10941** INSTRUMENTS AND MEASUREMENTS. Chemical Analysis, Electric Quantities, Nucleonics and Process Control. Proceedings of the Fifth International Instruments and Measurements Conference, September 13-16, 1960, Stockholm, Sweden. Helge von Koch and Gregory Ljungberg, eds. Volume 1. Automatic Process Control Physical Methods of Chemical Analysis. New York, Academic Press Publishers, 1961. 516p. $16.00.

The 1960 conference included 117 papers divided into the following sections: Automatic Process Control, Physical Methods of Chemical Analysis, Nuclear Instrumentation, Measurement of Electric and Magnetic Quantities, and Reactor Control. Volume 1 includes 49 papers on Automatic Process Control and Physical Methods of Chemical Analysis. Separate abstracts have been prepared for 14 papers from Volume 1. (M.P.G.)

**10942** MASS SPECTROMETRY. Hans von Ubisch (Aktiebolaget Atomenergi, Stockholm, Sweden). p.245-52 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The operation and components of mass spectrometers are summarized. Types of ion sources are briefly discussed. The ions from the material to be analyzed can be sorted according to their e/m value by means of magnets, nonmagnetic analyzers, which select ions according to their velocity, and resonance analyzers, such as the omegatron and the Farvitron. Ion currents are detected and recorded by photographic plates, Faraday cages, or electron multipliers. Some mass spectrometers are being equipped with direct data-handling equipment. The special problems of weak-intensity signals and background are discussed. (M.P.G.)

**10943** THE ANALYSIS OF SOLIDS BY MASS SPECTROMETRY. R. M. Elliott, R. D. Craig, and G. A. Errock (Associated Electrical Industries, Ltd., Manchester, Eng.). p.271-96 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

Techniques for chemical analysis of both inorganic and organic solids in the mass spectrometer are now well established. A new instrument in which impurities in inorganic solids can be detected at a concentration of 0.001 ppm (atomic) is described, and analyses of a variety of materials are presented. A high resolution instrument now being built for the investigation of complex organic compounds will permit identification of ions by means of mass measurement to a few parts in $10^6$. Chemical analysis by the isotope dilution method is also discussed. (auth)

**10944** THE ION PUMP. Wilson M. Brubaker (Bell and Howell Research Center, Pasadena, Calif.). p.297-304 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The design and operation of an ion pump to maintain ultralow pressures are described. Ions are made with a Penning discharge in a magnetic field. They are then used to achieve pumping action by burial in the cathode and by sputtering some of the cathode material on to other parts

of the apparatus. The cathode material reacts chemically with the molecules of many gases, thus removing them from the system. Experiments are described which show that the pumping action takes place at the cathode and not at the anode. By adding a second set of cathodes to obtain fresh deposits of cathode material (titanium), it was found that the pump operated stably with time, the pumping speed was increased, the life of the pump was increased, and the efficiency of operation remained high. It is concluded that the ion pump is the ideal means to achieve low pressures. It adds no contaminant to the vacuum system, its pumping action is independent of pressure, and there is no low-pressure limit to its operation. (M.P.G.)

**10945** THE QUADRUPOLE MASS FILTER. Wilson M. Brubaker (Bell and Howell Research Center, Pasadena, Calif.). p.305-15 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The operation of the quadrupole mass filter for satellite applications is investigated theoretically and experimentally. An experimental mass filter is described, and data are presented. It was found that the transmission efficiency is greatly influenced by the entrance conditions, that the stability in the x-z plane is quite different from that in the y-z plane, and that the spatial distribution of the fields at the entrance to the filter is of major importance. The quadrupole mass filter appears to be well suited for use as the analyzer part of a mass spectrometer for satellites. (M.P.G.)

**10946** BROAD-LINE NUCLEAR MAGNETIC RESONANCE AS AN ANALYTICAL TECHNIQUE. D. J. Ferrett (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.325-31 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The basic technique and apparatus used to apply nuclear magnetic resonance to quantitative analysis are described. The determination of light water in $D_2O$ and of residual H in highly fluorinated or deuterated compounds is described, and data are presented. Analysis of fluorine-containing organic molecules and other nuclei in the liquid state and the determination of H in solids are also described. (M.P.G.)

**10947** THE USE OF X-RAY METHODS IN CHEMICAL ANALYSIS. Cyrill Brosset (Chalmers Univ. of Tech., Gothenburg, Sweden). p.332-45 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

A survey is presented of x-ray analytical methods, including x-ray spectrography, x-ray fluorescent spectrography, x-ray absorption analysis, and the powder method of x-ray diffraction. The interactions of accelerated electrons and x rays with matter are reviewed. Diagrams are presented of some of the apparatus used in each of the analytical methods. (M.P.G.)

**10948** RECENT DEVELOPMENTS IN ARL X-RAY INSTRUMENTATION. E. Davidson and W. Ramsden (Applied Research Labs. Inc., Glendale, Calif. and Applied Research Labs. (GB) Ltd., Harpenden, Eng.). p.360-77 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The development of a vacuum Production X-Ray Quantometer, a smaller, general-purpose Vacuum X-Ray Quantometer, and an Electron Microprobe X-Ray Analyzer is described. Pictures and diagrams of the equipment are presented. The systems are based on the use of curved crystals, detectors which provide physical discrimination, and integration of the detector output by capacitors, which do not add noise or drift to the system. The charges on all integrators are read by a single electrometer amplifier and displayed on a strip-chart recorder. The instruments described are applicable to analytical control of industrial processes and to research on microstructures. (M.P.G.)

**10949** X-RAY FLUORESCENT ANALYSIS. H. J. Lucas-Tooth (Solartron Electronic Group Ltd., Farnborough, Hants., Eng.). p.378-84 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

Chemical analysis using x-ray fluorescent radiation from an unknown sample is described. The basic theory and equipment are reviewed, and the advantages of x-ray fluorescent analysis over optical emission spectrometry are discussed. Examples of results from typical operations are presented. X-ray techniques have been found to be particularly valuable in the analysis of copper-base alloys, high-alloy steel, slag, and ores. (M.P.G.)

**10950** ISOFORMATION OF SAMPLES FOR OPTICAL AND X-RAY EMISSION SPECTROGRAPHY. G. Sundkvist and Å. Olofsson (Boliden Mining Co., Skelleftehamn, Sweden). p.385-93 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The pretreatment (isoformation) of samples for optical and x-ray spectrography to make samples of different origins fit the same analytical curves is described. The four main methods of isoformation are grinding with buffer, fusion, ion exchange, and sulfide precipitation. The methods are described, and results using the various methods are presented and discussed. In x-ray spectrography, isoformation of samples can eliminate errors caused by variations in particle size and chemical structure, but not errors due to chemical composition. Isoformation makes it possible to prepare standard samples of any desired composition independent of wet chemical analysis. (M.P.G.)

**10951** AN APPARATUS FOR THE PRELIMINARY EVAPORATION OF TRACE IMPURITIES FROM SPECTROGRAPHIC SAMPLES. Leon Pszonicki (Inst. of Nuclear Research, Polish Academy of Sciences, Warsaw). p.394-402 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In German)

An apparatus is described which is used for the evaporation of volatile and medium volatile trace impurities from samples of low volatility. The impurities were condensed on an auxiliary electrode on which they could be determined by spectral methods. This apparatus makes possible evaporation at arbitrary temperatures up to 2500°C with a very accurate regulation of this parameter. It insures a rapid and precise distillation of a large series of samples. This technique finds a broad application in the spectrographic study of materials which have so complex a spectrum that the determination of traces is impossible. It can also be used as an enrichment method to increase the detection sensitivity. (tr-auth)

**10952** A UNIVERSAL TECHNIQUE FOR THE SPECTRAL ANALYSIS OF POWDERS AND SOLUTIONS USING A THREE-PART SIEVE ELECTRODE. Julian Czakow (Inst. of Nuclear Research, Polish Academy of Sciences, Warsaw). p.403-8 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In German)

A fast, simple, and economical discharge method using a three-component sieve electrode was worked out. The method is suitable both for powder and liquid samples. Additional application possibilities have been tested for the method. (tr-auth)

**10953** A NEW PHOTOELECTRIC LEITZ SPECTROMETER FOR THE DIRECT READING SPECTRAL ANALYSIS. H. G. Krueger (Wissenschaftliche Abteilung der Ernst

Leitz G.m.b.H., Optische Werke, Wetzlar, Ger.). p.409-19 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In German)

The photoelectric Leitz spectrometer consists of the following parts: the actual grating spectrometer with the spark-arc stand, the exciting device, the electronic measurement and evaluation apparatus which contains the electronic device for the measurement of the photocurrent of the secondary electron multiplier, and the control and measurement desk. The design and performance of each component are described. An example of the use of the spectrometer in steel analysis is given. (J.S.R.)

**10954** THE APPLICATION OF GAS CHROMATOGRAPHY IN RARE GAS PRODUCTION. Gerhard Gnauck (VEB Technische Gase Werke, Berlin). p.435-46 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In German)

After general statement on rare gas analysis and the advantages of the application of gas chromatography, the apparatus and the filling of the columns are described. The molecular sieve is discussed. A highly sensitive heat conductivity cell, a flame ionization detector, and a radioactive beam ionization detector are used as detectors. The individual components of these detectors are described. The problems occurring in the production of He, Ne, Ar, K, and Xe are discussed, and the detection of trace impurities is considered. Quantitative evaluation and possible automation are discussed. (J.S.R.)

**10955** PRODUCTION GAS CHROMATOGRAPHY. G. Rath (Beckman Instruments G.m.b.H., Munich). p.498-506 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In German)

A production gas chromatograph, which maintained the efficiency of the columns by parallel hookup, was designed. The flow plan of the apparatus is shown, and typical measurements to test the operation and performance of the column are described. Graphs showing typical results are given. (J.S.R.)

**10956** INSTRUMENTS AND MEASUREMENTS. Chemical Analysis, Electric Quantities, Nucleonics and Process Control. Proceedings of the Fifth International Instruments and Measurements Conference, September 13-16, 1960, Stockholm, Sweden. Helge von Koch and Gregory Ljungberg, eds. Volume 2. Nuclear Instrumentation, Measurement of Electric and Magnetic Quantities, Reactor Control. New York, Academic Press Publishers, 1961. 707p. $22.00.

Volume 2 includes 68 papers on Nuclear Instrumentation, Measurements of Electric and Magnetic Quantities, and Reactor Control. Separate abstracts have been prepared for 41 papers from Volume 2. (M.P.G.)

**10957** SEMICONDUCTORS IN NUCLEAR INSTRUMENTATION. G. B. B. Chaplin (Plessey Co. Ltd., Hampshire, Eng.). p.509-18 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The performance of several semiconductor devices in nuclear instrumentation is reviewed. The use of transistors in wide-band pulse amplifiers and binary scalers is discussed, and circuit diagrams are given. The avalanche transistor is effective for generating a fast edge and a narrow pulse. Gallium arsenide diodes are useful in fast coincidence circuits and fast linear gates, while Boff diodes may be used to produce pulses to test fast nuclear circuits. The tunnel diode makes a simple and fast trigger circuit, and other applications are discussed. The use of p-n junctions as charged particle detectors is reviewed. It is concluded that semiconducting devices are versatile and unique for nuclear instrumentation. (M.P.G.)

**10958** AN ELECTRONIC GALVANOMETER BASED EXCLUSIVELY ON SEMICONDUCTOR ELEMENTS. E. Dissing-Soerensen (AB Atomenergi, Studsvik, Sweden). p.519-25 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

A galvanometer to be used with radiation detectors providing direct current is described. A silicon diode operated as a variable capacity is used as a chopper element. The d-c signal information, determining the reverse bias voltage of the diode, is converted to a f-m signal of a high-frequency carrier. This is demodulated by a conventional frequency detector, giving the signal as a d-c voltage. The characteristics of the silicon diode are discussed, and circuit diagrams are given for the oscillator and frequency detector. Standard silicon diodes may be used to amplify the current down to $10^{-11}$ amp, and diodes especially constructed with little effective junction area may increase the range. (M.P.G.)

**10959** A TRANSISTORIZED COUNTING-RATE METER. E. Dissing-Soerensen (AB Atomenergi, Studsvik, Sweden). p.526-33 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The design of a counting-rate meter for a survey neutron monitor is described. The detector consists of a $BF_3$ proportional counter for slow neutrons and a proton recoil proportional counter for fast neutrons. Other components are a preamplifier, pulse discriminator and diode pump, high-voltage power supply, and low-voltage stabilizer. Circuit diagrams are presented for the amplifiers and the discriminator and diode pump, and the operation of the circuits is analyzed. The frequency range of the ratemeter is 2 pulses/sec to 1000 pulses/sec, but higher frequencies would be possible. (M.P.G.)

**10960** RECENT DEVELOPMENTS IN HEALTH PHYSICS MONITORING INSTRUMENTS. G. D. Smith and D. Aliaga-Kelly (Plessey Nucleonics Ltd., Northampton, Eng.). p.555-63 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The improvements in the radiation detectors and electronic circuitry used in health monitoring instruments are surveyed. The use of semiconductors such as silicon junctions and cadmium sulfide as detectors is discussed. The use of scintillators such as NaI(Tl) has resulted in improved measuring techniques for gamma spectrometry, iodine monitoring, in vivo monitoring, pulse-shape discrimination, and activation analysis. The use of transistors in power supplies, d-c amplifiers, count integrators, pulse-height analyzers, and pulse-shape discriminators is discussed, and circuit diagrams are presented. (M.P.G.)

**10961** POSSIBILITY FOR THE INTRODUCTION OF HALOGEN COUNTERS IN DOSE OUTPUT MEASUREMENTS. F. Humbel and A. Stebler (Landis and Gyr A.G., Zug, Switzerland). p.564-7 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In German)

The advantages of a halogen counter for use in dose output measurements are discussed. It is concluded that with halogen counters as detectors, sensitive, small, and sturdy dose output measurement devices could be built. These devices would almost equal the ionization chambers with respect to overloading resistance and energy dependence. (J.S.R.)

**10962** HAND MONITOR FOR SIMULTANEOUS MEASUREMENT OF ALPHA AND BETA CONTAMINATION.

I. Ö. Andersson, J. Braun, and B. Soederlund (AB Atomenergi, Stockholm). p.568-78 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The design and operation of an instrument to detect $\alpha$ and $\beta$ contamination of the hands during a period of 10 sec are described. Simultaneous $\alpha$ and $\beta$ detection and high sensitivity were achieved by using 8 flow counters paired off in units of 2, one unit for each side of the hands. The detector design and properties are discussed in detail. Pictures of the equipment and a description of all the components are included. During its first year of operation, the apparatus showed satisfactory reliability and stability. (M.P.G.)

**10963** MEASUREMENT OF RADIOACTIVITY IN THE HUMAN BODY. I. Ö. Andersson and I. Nilsson (AB Atomenergi, Stockholm). p.579-94 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

A body counter is described which has been used since 1958 to control internal contamination in people and to make periodic measurements of the natural activity in a group of people. The apparatus, its characteristics, and its calibration are discussed. The radiation detector is a scintillation counter with a 4-in.-diam. by 4-in.-thick thallium-activated NaI crystal. The detector and subject are shielded by a steel room with walls 20-cm thick. Measurements of Cs and K body contents in Swedish people are reported and compare well with measurements by other laboratories. The average $Ca^{137}$/K ratio in $\mu\mu c$/gK decreased from 74 to 55 from May 1959 to June 1960. Since there were no nuclear bomb tests since 1958, this indicates that a considerable part of $Cs^{137}$ enters the biosphere by direct fallout. Measurement of a few cases of internal contamination is described. (M.P.G.)

**10964** THE PRESENT STATE OF SCINTILLATION TECHNIQUES. R. B. Owen (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.595-615 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The uses, limitations, and recent improvements in scintillation detectors are reviewed. The pulse-amplitude resolution in Tl-activated NaI crystals is not simply determined by statistical variations in the number of photoelectrons, and attempts to explain this phenomenon are discussed. The variation in pulse shape or decay time with specific ionization in organic and inorganic phosphors is analyzed, and methods to utilize this variation to identify particles are described. Attempts to improve the time resolution of scintillation counters are reviewed. Devices capable of imaging single photoelectron tracks have been developed recently, and track imaging systems are discussed in detail. One of the major limitations to scintillation techniques is the large amount of energy required from the primary particle to produce a single photoelectron. Attempts to overcome this are described. (M.P.G.)

**10965** GLASS SCINTILLATORS FOR THE DETECTION OF NUCLEAR RADIATIONS. D. G. Anderson, J. Dracass, and T. P. Flanagan (British Scientific Instrument Research Assn., Chislehurst Kent, Eng.). p.616-30 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The presence of cerium in the reduced state ($Ce^{3+}$) in glass compositions produces glass scintillators capable of detecting $\alpha$, $\beta$, and $\gamma$ radiations. Detection of thermal neutrons is made possible by the presence of lithium in the glass. Preparation of the glasses, the effect of the variation of Ce content on the relative pulse heights, the effect of iron impurities on efficiency, and the transmission and emission characteristics, physical properties, and radiation response of the glasses are discussed. The maximum pulse-height efficiencies obtained are in the region of 15% relative to NaI(Tl) crystals. Glass scintillators have a high chemical durability and can be prepared in various geometric forms. (M.P.G.)

**10966** ABSOLUTE ACTIVITY MEASUREMENTS BY MEANS OF LIQUID SCINTILLATORS. S. Hellstroem (AB Atomenergi, Stockholm). p.631-40 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The method and apparatus used to measure the absolute activity of some $\beta^-$, $\beta^+$, and $\alpha$ emitters in a liquid scintillation counter are described, and the results are compared to standardized values obtained by the $4\pi$ proportional counting technique. To obtain the $\beta$-emission rate, the counting rate is plotted as a function of pulse-height-discrimination level. The plot should be a straight line, and the emission rate is found by extrapolating to zero discrimination. A variation in gain of the counter should also give straight lines with the same value of the emission rate, so 2 or 3 plots were made for comparison. Reliable results were obtained for high- and medium-energy $\beta$ emitters. It is expected that it should be possible to measure $\beta$ emitters above ~0.2 Mev with the same accuracy as that of $4\pi$ proportional counters. It should not be difficult to standardize $\alpha$ emitters by this method, if the isotopes can be combined with the scintillator without reduction of the efficiency. (M.P.G.)

**10967** CONTROLLABLE IONIZATION CHAMBERS. F. Humbel and A. Stebler (Landis and Gyr, Zug, Switzerland). p.641-4 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In German)

An ionization chamber which has a controllable voltage on the control electrode and on the counter electrode is described. This ionization chamber has a cylindrical collection electrode about which are arranged rectangular plane plates so that they form the surface of a regular prism coaxial to the collection electrode. The plates can be curved so that they form the arc of a circle. The plates are isolated from each other, but every other one is connected. One group of plates form the counter electrode, and the other group, the control electrode. The effects of inaccuracies in the construction of such a chamber are discussed. (J.S.R.)

**10968** RECENT DEVELOPMENTS IN PORTABLE MEASURING INSTRUMENTS. S. R. Wilkins (AVO Ltd., London). p.645-62 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

A small ionization chamber with a direct-reading, electrometer-type, vacuum-tube voltmeter is considered to be the best type of personal radiation monitor because of simplicity, low production costs, the small size requirements for batteries, and the ease of reading by nontechnical personnel. An instrument of this type, the Radiac survey meter, and a similar instrument for remote readings are described, and circuit diagrams are given. The design and performance of a light-weight d-c amplifier for ionization current measurements and an experimental self-indicating magnetic memory scaler are discussed. A portable transistor analyzer for testing and measuring low-frequency transistor parameters is also described. (M.P.G.)

**10969** A FABRY-PEROT SPECTROMETER FOR ISOTOPIC ANALYSES. R. P. Thorne (United Kingdom Atomic Energy Authority, Capenhurst, Ches., Eng.). p.668-73 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

A Fabry-Perot etalon, consisting of two parallel plates separated by an air space, the inside surfaces of the plates being coated with high-reflectivity films, can be used in place of a grating in a spectrometer. The design of a spectrometer for the determination of isotopic abundances is described. Pressure scanning, i.e., variation of the refractive index of the space between the etalon plates, was obtained by controlling the leakage from a pressurized chamber containing the plates by a magnetically operated valve. Preliminary results indicate that isotopic abundances can be measured to a precision of better than 1% of the isotopic ratios. (M.P.G.)

**10970** THE ROUTINE DETERMINATION OF THE ISOTOPIC ABUNDANCE OF URANIUM USING A DIRECT-READING ECHELLE GRATING SPECTROGRAPH. W. Fletcher (United Kingdom Atomic Energy Authority, Capenhurst, Ches., Eng.). p.674-85 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The construction of a simple and compact spectrograph with sufficient dispersion and resolving power to separate the isotopic lines of uranium is described. The spectrograph employs an echelle type grating in a Littrow mounting, and the photoelectric recording head uses fixed slits for admitting the spectral radiations to the photomultiplier tubes. The electronic recording unit employs commercially available operational amplifiers, and the advantages of this system are discussed. Automatic control and recording of the results are discussed, and a system using a digital voltmeter and an electrically operated adding machine is described. A hollow cathode source is used for the excitation of the uranium, and the variables which need careful control are considered. The paper concludes with an account of the experience gained with this spectrograph under routine conditions. (auth)

**10971** DETERMINATION OF URANIUM ISOTOPES BY MEANS OF DIRECT-READING EMISSION SPECTROSCOPY. W. de Nie (Baird-Atomic Inc., Cambridge, Mass.). p.686-94 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

Spectroscopic equipment of standard design was used to analyze $U^{235}$, $U^{236}$, and $U^{238}$ using spectral lines in the vicinity of 4244 Å. An optical beam-splitting device to separate the spectral lines and permit the light to be received by photomultiplier tubes was added and is described. The design of an automatic servo monitor to maintain optical alignment is discussed. Sample preparation and excitation are described, and analytical results are presented. (M.P.G.)

**10972** AN ACIDITY METER FOR MONITORING ACTIVE URANYL NITRATE SOLUTIONS. E. Duncombe, A. W. Fenton, and A. J. Walton (United Kingdom Atomic Energy Authority, Capenhurst, Ches., Eng.). p.695-704 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

An instrument is described which was designed to measure the free acidity or U concentration of U solutions by determining the density and conductivity of the solutions. The components to measure density and conductivity are described and diagrammed. The signals from the components are displayed on an "X,Y" self-balancing potentiometer. For automatic control purposes, a signal proportional to deviations from the desired value of acidity is obtained by a resolver network. Free acidity was determined within 3.5% and U concentration within 4% from individual readings of density and concentration. Similar accuracy was obtained using the resolver over the interval $\pm 0.5\underline{N}$ of the nominal acidity and ±60 g/l of U. Errors increase significantly with larger excursions from nominal values. (M.P.G.)

**10973** PULSE-COUNTING PERIOD METER. J. Bjoerkman (AB Atomenergi, Studsvik, Sweden). p.705-10 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

A direct-reading instrument to measure the time interval in which the power of a starting reactor is doubled is described. Pulse and digital techniques are used, and circuit diagrams are presented. A sequence of 7 doubling times can be measured and are recorded by clock pulses on mechanical registers. The accuracy is ~ ±0.2 sec for doubling times in the 20 to 200 sec range. The range is limited by the dead time of the detector and amplifier. (M.P.G.)

**10974** A CALORIMETER FOR WIGNER ENERGY MEASUREMENTS. D. F. Davidson and E. Duncombe (United Kingdom Atomic Energy Authority, Capenhurst, Ches., Eng.). p.711-16 of "Instruments and Measurements." New York, Academic Press Publishers, 1961.

A linear-rise adiabatic calorimeter was designed to study the stored energy content of irradiated graphite for annealing temperatures up to 800°C. Two identical specimens, one irradiated and one not, are placed in the same calorimeter. The difference in power supplied to raise their temperatures at the same rate is the power released, which is a measure of the stored energy. Typical graphs of the rate of stored energy as a function of temperature are shown. The accuracy of measurement is estimated at about ±0.01 cal/g per °C. Diagrams of the calorimeter are given, and the operation of the equipment is described. (M.P.G.)

**10975** INSTRUMENT FOR MEASURING X-RAY ENERGY. M. Varičak and B. Saftić (Ruder Bošković Inst., Zagreb). p.717-19 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

An absorption method for measuring the intensity of x-ray beams in described. A thermistor made of magnetite, with small quantities of Mg, Mn, and Ti added, and covered with a film of lead oxide was found to absorb ~100% of a 37-ke x-ray beam. The change in resistance of the thermistor is a measure of the intensity of the incident x rays. The equipment and circuitry are described. The sensitivity was found to be ~400 r/hr. (M.P.G.)

**10976** MULTIDIMENSIONAL ANALYSERS. R. Wahl (Intertechnique, Nuclear Division, Versailles, France). p.720-6 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The components of multidimensional analyzers are reviewed, and some examples of complete instruments are presented. Amplitude and time converters and storage elements are described. A 1024-channel memory core storage, a 1024-channel time-of-flight analyzer, and a 4096-channel multidimensional analyzer are discussed. Multidimensional analyzers are useful in coincidence analysis, neutron activation analysis, and where multiple inputs are required, such as in the use of large Cherenkov crystals. (M.P.G)

**10977** A CHEMICAL VIEW OF INDUSTRIAL ISOTOPE APPLICATIONS. G. B. Cook (International Atomic Energy Agency, Vienna). p.727-32 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

Recent developments of interest to the chemist are reviewed. The use of multichannel analyzers and small pulsed neutron-generating machines in radioactivation analysis is discussed, and the use of radioactive isotopes in gas analysis is mentioned. X-ray fluorescent spectroscopy can be simplified by the use of a radioactive source instead of an

x-ray tube. The preparation of tritiated compounds is discussed. The use of radioactive isotopes in the oil industry and isotope techniques in the study of catalytic processes and reaction kinetics are mentioned. (M.P.G.)

**10978** THE SENSITIVITY AND ACCURACY OF THICKNESS MEASUREMENTS USING THE PENETRATION METHOD WITH RADIONUCLIDES. Heinrich Mueller (Frieseke and Hoepfner G.m.b.H., Erlangen-Bruck, Ger.). p.733-45 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In German)

The factors affecting the sensitivity and accuracy of thickness measurements are discussed. An example is given of thickness measurements with exponential attenuation of the beam penetration. The different sensitivity parameters are described, and different radiators are compared. The effect of systematic and accidental errors on the accuracy is shown. The comparability of the corrected sensitivity as a measurement of the accuracy is discussed. (J.S.R.)

**10979** A BETA PARTICLE THREAD THICKNESS GAUGE. R. K. Barnes and J. H. Barrett (Department of Scientific and Industrial Research, Eng.). p.746-56 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The design of an instrument to measure textile thread thicknesses in the 50 to 300 denier range is described. The source, slit, and detector arrangement and associated circuitry are described and illustrated. $Kr^{85}$ is used as the $\beta$-particle source. The short-term stability is equivalent to 1 denier, and the long-term stability, over a 16-hr period, is ~4 denier. The instrument has only been produced in experimental form, but it appears to have worthwhile advantages over other thread gages. (M.P.G.)

**10980** TWO TYPES OF BETAMETERS USED IN PULP AND PAPER RESEARCH. Olle Fineman (Karlstads Mekaniska Werkstad, Karlstad, Sweden). p.757-62 of "Instruments and Measurements." New York Academic Press Publishers, 1961. (In English)

An instrument is described which was designed to measure and record variations in difference in area-weight or water content between two places in a pulp or paper machine. The equipment consists of two $\beta$ sources, two identical measuring lines consisting of a control unit and a measuring head of the balanced-ionization-chamber type, a difference amplifier, and a recorder. An instrument which graphically records the structure of a paper web is also described. A $\beta$ source and a Geiger-Müller tube are used to measure area-weight in specific parts of the paper. Pictures and diagrams of both instruments are presented. (M.P.G.)

**10981** ON THE POSSIBILITY OF MOISTURE DETERMINATION BY BETA-RAY TRANSMISSION. T. Westermark, B. Sjoestrand, and H. G. Forsberg (Royal Inst. of Tech., Stockholm). p.763 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The drying of a sheet material between two places in the fabrication line can be measured by two $\beta$-transmission gages coupled against one another and appropriately balanced. The possibility of using this technique in cases involving special drying of the material is mentioned but not discussed. (M.P.G.)

**10982** THE MEASUREMENT OF VOLTAGE, CURRENT AND MAGNETIC FIELD IN PULSED TOROIDAL GAS DISCHARGE APPARATUS AT HARWELL. E. P. Butt and A. B. Gillespie (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.938-73 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The methods of making electrical measurements on toroidal "pinched" discharge machines are described. Potential dividers and Rogowski coils are most frequently used for voltage and current measurements because of the relative ease with which they may be fitted to experimental apparatus. Shunts and current transformers are also used. Design criteria for these devices are discussed. The magnetic field configuration is measured by probes containing small pick-up coils. The electronic circuits necessary to transmit signals from the pick-up devices over a considerable distance to the recording instruments are described, along with circuits for addition, subtraction, amplification, integration, differentiation, and multiplication. Storage oscilloscopes are used to observe and monitor electrical measurements during an experiment. Characteristics of recently developed storage tubes are discussed. The advantages, disadvantages, and errors involved in recording the signal photographically for further study are analyzed, and a signal sampling system for recording information is diagrammed. The use of computer techniques, the calibration and accuracy of the equipment, and possible future developments are also discussed. (M.P.G.)

**10983** REACTOR CONTROL. T. Coxon (Nuclear Power Group, Knutsford, Ches., Eng.). p.1027-50 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The dynamic behavior of graphite-moderated, gas-cooled reactors and the conception, basic design, and operation of automatic control systems are discussed. Reactor station parameters are reviewed. Conventional instrumentation can be used for almost all measurements except flux monitoring and scanning and burst fuel cartridge detection. Basic reactor kinetic and thermodynamic equations are derived for a general interpretation of a reactor transfer function, and a block diagram of the equations is obtained. The design of loops for power control and rod control is considered. Reactor control technology uses proven existing equipment to a large extent, although new developments in the measurement and indication field were and still are required. (M.P.G.)

**10984** SOME ASPECTS OF STABILITY STUDIES RELATED TO THE CONTROL OF POWER REACTORS. R. I. Vaughan and R. N. H. McMillan (United Kingdom Atomic Energy Authority, Risley, Lancs, Eng.). p.1051-5 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The problem of achieving flux stability in the core of large graphite-moderated gas-cooled thermal reactors is considered. Stability in the total power output is analyzed, assuming constant coolant flow and reactor inlet temperature conditions. If the initial excursion limited by the fuel temperature coefficient is acceptable, a control system with an error signal based on the measurement of coolant outlet temperatures is sufficient. Axial and radial stability in the shape of the neutron flux distribution within the core is also discussed. Causes of radial instability are listed. (M.P.G.)

**10985** CONTROL OF THE MARINE STEAM COOLED REACTOR. M. H. Kendon and R. Hetherington (Rolls-Royce Ltd., Derby, Eng.). p.1056-75 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

Digital and analog computer techniques are used to study the behavior of a steam-cooled type of reactor for marine propulsion. A typical reactor moderated by $D_2O$ is de-

scribed. The moderator control tubes can be filled or emptied to adjust the reactivity of the reactor. Therefore, the neutron physics constants vary greatly between regions with full and empty control tubes, making computation difficult. The analysis of transients by a 6-point analog representation with the single-point neutron equations and by a digital computer program solving the heat transfer and single neutron energy group diffusion equation in a many region reactor is presented. Satisfactory agreement between the two methods was obtained for the times involved in transients and for outlet temperatures. Once the equations have been set up on the computer, a large number of transients can be investigated in a short time by the analog approach, making this method suitable for use in a representation of the whole plant. In this type of reactor, performance, economy, and lifetime could be improved by improving the methods of adjusting the radial power pattern. (M.P.G.)

**10986** A REVIEW OF RECENT DEVELOPMENTS IN THE DESIGN OF NEUTRON SENSITIVE DETECTORS FOR USE IN POWER REACTORS. A. L. Gray (Plessey Nucleonics Ltd., Northampton, Eng.). p.1076-84 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

Radiation detectors have been developed which have high sensitivity and are well suited for use in reactors where space is limited. The detectors are a boron-lined proportional counter, which can be left without damage in very high neutron fluxes, a compensated ionization chamber, and a fissile-coated ionization chamber, which may be used as a pulse counter or a mean current detector. The design and performance of each detector are described. The three detectors are capable of covering the entire operating range of a reactor from source level to full power. (M.P.G.)

**10987** NEW DEVELOPMENTS IN FISSION CHAMBER DETECTORS FOR NEUTRON FLUX MEASUREMENTS. W. Abson, W. R. Loosemore, and P. G. Salmon (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.1085-1103 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The development of fission ion chambers capable of operation at very high temperatures and covering neutron flux measurements from ~10 to $10^{13}$ n/cm$^2$/sec is reported. The general principles of design and construction of fission chambers for high-temperature operation are discussed. The design and performance of the following types of fission chambers are described: mean-current ionization chambers suitable for measurements at very high neutron flux, high sensitivity pulse counters for measurement of low neutron flux intensities, and miniature counters for flux distribution measurements. The counters can be operated at temperatures up to 500°C, and one type of counter was used at 900°C. The high-temperature electrical and vacuum properties of metal-ceramic seals are the main factors limiting high-temperature operation. (M.P.G.)

**10988** UNIQUE POSITIONING SYSTEM FOR SOLID-STATE FISSION PROBE PERMITS RAPID LOW POWER FLUX MAPPING IN PLATE-TYPE FUEL ELEMENTS. Robert Steinberg (National Aeronautics and Space Administration, Cleveland). p.1104-14 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

A power survey instrument using a solid-state detector was designed for use in pool or tank reactors with Al-clad plate-type fuel elements, but is adaptable to most solid-fuel cores. The semiconducting detecting element consists of 10 silicon p-n junction wafers in series, each wafer being coated with 90% enriched $U^{235}$. The design of the instrument and the underwater positioning system are described, and operating characteristics are reported. The fission probes have proved to be rugged and dependable, and the instrument should permit rapid low-power flux mapping in previously inaccessible core regions. (M.P.G.)

**10989** APPLICATIONS OF TRANSISTOR TECHNIQUES IN REACTOR INSTRUMENTATION. G. G. Ballard (Elliott Nucleonics, London). p.1115-31 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

A survey of reactor control circuits using transistors is presented. Included in the discussion are the detection and amplification of low voltage signals from low impedance circuits, the measurement of small direct currents from high impedance sources, pulse-counting equipment, d-c trip units, and fail-safe logic circuits. (M.P.G.)

**10990** INTRODUCTION OF MAGNETIC AMPLIFIERS IN REACTOR INSTRUMENTATION. P. Schranz and A. Stebler (Landis and Gyr A. G., Zug, Switzerland). p.1132-7 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In German)

The principle and performance of magnetic amplifiers for instrument monitoring in reactors are briefly described. (J.S.R.)

**10991** REVIEW OF RECENT DEVELOPMENTS IN THE DESIGN OF BURST FUEL ELEMENT DETECTION SYSTEMS FOR POWER REACTORS. G. V. Hough (Plessey Nucleonics Ltd., Northampton, Eng.). p.1138-43 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

In power reactors an economic balance must be achieved between the utilization of the fuel (which includes the complexity of the fuel handling system) and the amount of equipment provided for burst cartridge detection. Types of bursts and methods of detecting bursts are described. The advantages of a continuous-monitoring matrix system are discussed. (M.P.G.)

**10992** A FAST SCANNING EQUIPMENT FOR THE SURVEY OF FUEL CHANNEL TEMPERATURES IN A NUCLEAR REACTOR. B. Lundell and O. Rydén (AB Atomenergi, Tystberga, Sweden and ASEA, Västerås, Sweden). p.1144-9 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The design and operation of a fast and accurate system for fuel temperature survey in pressurized water-cooled power reactors are described, and circuit diagrams are presented. (M.P.G.)

**10993** A SIMPLE AND CHEAP XENON PREDICTOR FOR HIGH FLUX REACTORS APPLYING A NEW PRINCIPLE. O. Rydén and C. A. Bergqvist (ASEA, Västerås, Sweden). p.1150-6 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

A method for the prediction of xenon buildup is described, which uses resistance-capacitance networks in combination with cathode followers. The circuit parameters are derived, and a diagram of the predictor circuit is presented. The predictor, using an accelerated time scale, may be used to simulate xenon concentration by using a step-by-step calculation method. (M.P.G.)

**10994** SOME ASPECTS OF THE CONTROL AND INSTRUMENTATION OF GAS-COOLED REACTOR POWER STATIONS. B. H. Stonehouse (General Electric Co. Ltd., Erith, Eng.). p.1157-68 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

Developments and improvements in instrumentation,

data collecting and processing equipment, and overall control equipment for $CO_2$-cooled, graphite-moderated, natural U reactors are reviewed. Equipment for reactor-core temperature scanning, burst-cartridge detection, and flux control is described and diagrammed. (M.P.G.)

**10995** OPERATIONAL VIEW OF INSTRUMENTATION IN NUCLEAR POWER STATIONS EMPLOYING GAS-COOLED REACTORS. D. R. R. Fair and J. McCrickard (United Kingdom Atomic Energy Authority, Chapelcross, Scotland). p.1185-99 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

The instrumentation provided in the United Kingdom Atomic Energy Authority's nuclear power stations in Calder Hall and Chapelcross is reviewed under the headings of safety, operation and development. The relationship between the operator and his instruments and the methods of presenting information in order to acheive safety and efficiency are discussed. The operator's view of the instrumentation and a safety philosophy for control rooms of nuclear power stations is given. (auth)

**10996** PROCESS INSTRUMENTATION FOR NUCLEAR POWER REACTORS. THE BUYER'S AND USER'S VIEW ON THE APPLICABILITY OF COMMERCIALLY AVAILABLE EQUIPMENT. Peter Hjertberg (ASEA, Västerås, Sweden). p.1200-7 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

Process instrumentation for the measurement of pressure, flow, level, and temperature in water-cooled reactors is discussed. General requirements are listed, electric and penumatic systems for the transmission of information are discussed, and different types of measuring equipment are described. Commercially available instrumentation can be used without alteration in many cases. (M.P.G.)

**10997** EXPERIENCES OF INSTRUMENT MAINTENANCE AT CALDER HALL. R. C. Vincent (United Kingdom Atomic Energy Authority, Windscale, Eng.). p.1208-27 of "Instruments and Measurements." New York, Academic Press Publishers, 1961. (In English)

Instrument maintenance during the construction of the reactor, fuel loading, and reactor start-up is described, and a procedure for installation and commissioning is recommended. Early instrument problems at Calder Hall are reviewed. Recommended procedures for routine maintenance and maintenance during reactor shut-down are described. (M.P.G.)

## Radiation Detection

*Refer also to abstracts 10532 and 11638.*

**10998** (AERE-R-4189) RECENT DEVELOPMENTS IN CHEMICAL METHODS OF RADIATION DOSIMETRY. D. J. Morgan (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). Dec. 1962. 20p.

Some developments from 1958 to 1962 in chemical methods of radiation dosimetry are reviewed. The review is divided into classical methods, polymeric systems, chemical measurements, and new techniques; the approximate ranges of the individual methods are tabulated and 65 references given. (auth)

**10999** (ANL-FGF-340) AN EVALUATION OF A FAST, SCINTILLATOR-POLAROID FILM CAMERA FOR NEUTRON IMAGE DETECTION. Harold Berger and I. R. Kraska (Argonne National Lab., Ill.). Apr. 1962. Contract [W-31-109-eng-38]. 11p. (UAC-6345)

A new Polaroid camera for detecting thermal neutron images was subjected to a series of tests to determine its usefulness for neutron radiography. Because the response of this detector is extremely fast and convenient the camera can be highly recommended for alignment procedures and for preliminary radiographic exposures. The high contrast resolution capability in the order of 0.002 in. is also an asset which contributes to the utility of the camera. However, the fact that the detector appears to yield contrast sensitivities only in the order of 12 to 15% may limit its usefulness for more general radiographic work. (auth)

**11000** (BNL-6094) A BUBBLE CHAMBER TRACK-CENTERING DEVICE WITH DIGITIZED OUTPUT. Frederick Ayer, Eric Pickup, Edwin F. Rappe, and Gaylord Wall (Brookhaven National Lab., Upton, N. Y.). Mar. 1962. Contract [AT(30-2)-Gen-16]. 18p.

A means for automatically determining the coordinates of a point at the center of a bubble chamber track is described. A coarse setting of operator-controlled cross-hairs, supported by a toolmaker's stage, is made and the distance between the cross-hairs and the track center is found by means of a system based on a vibrating slit that scans a portion of the track. The distance is reduced to digital form and printed out on tape along with the coordinates of the coarse stage setting. A computer routine then determines the true position of the point on the track. Diagrams of the apparatus are included. (auth)

**11001** (BNL-6095) A VERSATILE BUBBLE-CHAMBER TRACK MEASURING STAGE. Frederick Ayer, II, and Ernest M. Bolze (Brookhaven National Lab., Upton, N. Y.). Mar. 1962. Contract [AT(30-2)-Gen-16]. 25p.

A measuring stage for bubble chamber film, with some interesting features in both its film transfer mechanism and its stage motor drive, is described. Power for the stage motion is supplied by pairs of motors geared to differentials, the speed of one motor being controllable. Lead screw speed is, therefore, continuously variable in both directions. Measurement of coordinates of points on a track with the assistance of a track centering device is outlined. The film transfer mechanism will accommodate four stereo-views on separate films on any width from 35 to 70mm and any length from 100-ft spools to 1000 ft, wound on cores, with the maximum ease of convertibility. (auth)

**11002** (CNEN-158) INDAGINE TEORICO-SPERIMENTALE SUI CONTATORI A PROTONI DI RINCULO ESPOSTI AD UNA SORGENTE DI NEUTRONI VELOCI. (Theoretical-Experimental Investigation of a Proton-Recoil Counter Exposed to a Fast Neutron Source). L. Sani, L. Tondinelli, and F. Zanchi (Rome. Universita). Jan. 1962. 58p.

In order to investigate the possibility of using a proton-recoil proportional counter filled with $H_2$ and lined with solid radiator for fast neutron spectrometry, the theoretical counting rate as a function of neutron energy was examined. The expression of the counting rate for non-monoenergetic neutrons in the form of a matrix suggests a method for the determination of the fast neutron spectrum from the differential pulse-height curve of the counter placed in a neutron flux. (auth)

**11003** (HW-72512) SCINTILLATING GLASSES FOR ALPHA COUNTING. U. L. Upson (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Jan. 29, 1962. Contract AT(45-1)-1350. 21p.

Two types of cerium-activated scintillating glasses were tested as alpha detectors: low-silica Li-Mg-Al glasses and activated Vycors. These phosphors are of interest as alpha detectors particularly with respect to their applicability to the continuous monitoring of liquid process

streams. Although inferior to protected phosphors of silver-activated zinc sulphide in quantum efficiency (pulse height) and beta discrimination, both types of glasses exhibit superior energy resolution and higher counting yields, as well as outstanding chemical resistance and rapid decontamination. The low-silica glasses were found superior to the Vycor glasses, quantum efficiencies relative to unprotected ZnS(Ag) being 7.5 to 9% and 2.0 to 4.8%, respectively. The difference between the glasses is due in part to self-absorption of scintillations in the Vycor, which exhibits the characteristic ceric color; and therefore can be minimized by employing thin sections. Such thin sections also yield improved discrimination against beta and gamma, and in this respect the Vycor glasses appear to be better than the low-silica glasses. The durability and fast recovery of the glasses make them superior to inert-film-covered ZnS screens for liquid-contact applications, although their lower pulse height requires low-noise amplification. (auth)

**11004** (HW-SA-2651) PIPING AUTORADIOGRAPHY. L. D. Perrigo and W. E. Taylor (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). June 25, 1962. Contract AT(45-1)-1350. 5p.

A new technique is described for radiographing the whole interior surface of pipes. The technique comprises cutting a fine-grain, high-contrast x-ray film so that it has a width slightly larger than the inside pipe circumference, covering both sides of the film with plastic sheet, rolling and inserting the film as a scroll into the pipe, and inserting heavy-walled surgical tubing through the center of the scroll. One end of the tubing is clamped, and the tubing is inflated with water to effect close film contact with the pipe. An example of the use of the technique is given for a carbon steel pipe which was in an in-reactor loop. (D.L.C.)

**11005** (IKF-5) AUFBAU UND UNTERSUCHUNG EINES GASSZINTILLATIONSZÄHLERS. (Construction and Study of a Gas Scintillation Counter). U. Strohbusch (Johann-Wolfgang-Goethe-Universität, Frankfurt am Main. Institut für Kernphysik). July 1962. 43p.

A gas scintillation counter was built and the intensity of the impulses developed by $Po^{210}$ $\alpha$ particles in Xe, He, and He–Xe mixtures was compared with the intensity of the emitted impulses by these $\alpha$ particles in a CsI(Tl) crystal and their pressure dependence was measured. The gas scintillation impulses were optimally about a factor of 1.2 larger than the CsI(Tl) impulses. They had a rise time of 20 nsec. The smallest relative half width of the $\alpha$ peaks amounted to 5%. Further investigations covered the gamma sensitivity, the stability of the counter, and the influence of impurities. For investigation of the impulse intensity relation to energy, neutrons of various energies were bombarded on a scintillation gas mixture of He + 20% Xe. The intensity of the back-scattered helium nuclei in impulses emitted in the gas mixture was directly proportional to the kinetic energy of the particle. In the same way the intensity relation of the impulse, which was released by the He and Li nuclei from the reaction $B^{10}(n,\alpha)\,Li^{7}$ in Xe, corresponded to the energy relation of the particles. (tr-auth)

**11006** (NP-12376) AN EVALUATION OF CADMIUM SULFIDE AS A NUCLEAR RADIATION DETECTOR (thesis). Darrel Leroy Mills (Air Force Inst. of Tech., Wright-Patterson AFB, Ohio). Aug. 1962. 62p. (GNE/Phys/62-10)

Solid state radiation detectors were constructed using crystal platelets of CdS. Both intrinsic and p-n junction detectors were made and evaluated. Although alpha particles were detected by both types of detectors, the mobility-lifetime product of the charge carriers resulted in the pulse response not being proportional to the energy of the incident particle. The best experimental value for the mobility-lifetime product in CdS was $2.6 \times 10^{-6}$ cm$^2$/volt for the electrons and $2.1 \times 10^{-6}$ cm$^2$/volt for the holes. Also an experimental value of 5.2 ev dissipated per hole-electron pair formed was determined. A resolution of 6.8% was obtained with one detector. Other phenomena such as the trapping of the charge carriers and the ionization of neutral impurity atoms also were evident in the crystal. (auth)

**11007** (TID-15765) PORTABLE RADIAC EQUIPMENT AT SANDIA—ITS CALIBRATION AND USE. G. E. Tucker, Jr. (Sandia Corp., Albuquerque, N. Mex.). Apr. 3, 1962. Contract [AT(29-1)-789]. 4p. (SCDC-2633X)

The use of portable radiac equipment at Sandia is discussed. Topics covered include: work at Sandia, instruments, personnel, and calibration of equipment. (M.C.G.)

**11008** (TID-16174) CHARACTERISTICS OF A HEAVY-ION DETECTION SYSTEM. J. A. McIntyre, T. L. Watts, and F. C. Jobes (Yale Univ., New Haven). [1962]. Contract [AT(30-1)-2726]. 58p.

The characteristics of a heavy-ion detection system are considered. The detection of the heavy ions is achieved by collecting the radioactive ions in stacked foils and measuring the radioactivity of the foils. Although the system is limited to detecting radioactive isotopes, 10 interesting reactions can be investigated: 4 neutron stripping reactions, ($C^{12}$, $C^{11}$), ($N^{14}$, $N^{13}$), ($O^{16}$, $O^{15}$), and ($F^{19}$, $F^{18}$); 4 proton pickup reactions, ($B^{10}$, $C^{11}$), ($C^{12}$, $N^{13}$), ($N^{14}$, $O^{15}$), and ($O^{16}$, $F^{17}$); and 2 nucleon interchange reactions, ($B^{11}$, $C^{11}$), and ($N^{14}$, $O^{14}$). The energy resolution of the system varies from 0.7 to 0.4 Mev (full-width-at-half-maximum). The outstanding feature of the system is its high discrimination against the detection of stable isotopes. A system that has been constructed is described. (auth)

**11009** (TID-16206) SOLID STATE PARTICLE DETECTORS. Niels Hansen (Argonne National Lab., Ill.). May 1962. Contract [W-31-109-eng-38]. 15p. (UAC-6421).

The properties of the p-n junction and how it detects ionizing radiation are discussed. The types of semiconductor detectors in use and some of the techniques involved in their fabrication are described. The intrinsic semiconductor, impurity semiconductor, p-n junction, surface-barrier junction, diffused junction detector, lithium drifted detector, and surface-barrier detector are discussed. Advantages over other types of detectors are listed. (M.C.G.)

**11010** (TID-16311) PULSED ELECTROSTATIC ANALYZER FOR ION ENERGY DETERMINATIONS. F. A. White, J. C. Sheffield, and P. H. McDonald (Knolls Atomic Power Lab., Schenectady, N. Y.). May 21, 1962. Contract W-31-109-eng-52. 5p.

Construction and operation of an analyzer that provides both mass and energy resolutions of ion beams is discussed. This analyzer consists of a double-pulse generator that pulses the ion source and "gates" the electron multiplier detector output, and a multiple slit system for "scanning" the electrostatically analyzed ion beam. A schematic diagram of the electrostatic analyzer with time-of-flight circuitry is presented. (H.G.G.)

**11011** (TID-17824) THE CONSTRUCTION AND PERFORMANCE OF A MUSCLE-EQUIVALENT ENVIRONMENTAL RADIATION METER OF EXTREME SENSITIVITY. Jacob Kastner, John E. Rose (Argonne National Lab., Ill.); and Francis R. Shonka (Saint Procopius Coll., Lisle,

Ill.). Nov. 1962. Contract [W-31-109-eng-38]. 15p. (UAC-7084)

A very sensitive environmental radiation monitoring system and some of the work done so far with it are described. The system comprises a Shonka vibrating electrometer and a muscle-equivalent ion chamber. Measurements of environmental backgrounds are reported. (D.L.C.)

**11012** (UCRL-6692) PLUTONIUM ALPHA AIR MONITOR USING A SOLID STATE DETECTOR. W. A. Phillips and C. L. Lindeken (California. Univ., Livermore. Lawrence Radiation Lab.). Apr. 16, 1962. Contract W-7405-eng-48. 14p.

A continuously indicating Pu alpha air monitor using a P–N junction Si detector and single-channel pulse-height analyzer is described. The resolution of the system excludes 98% of the radon daughter alpha activity. One MPC of $Pu^{239}$ can easily be seen within 8 hours of sampling. (auth)

**11013** (UCRL-6845) A STUDY OF COLLECTOR ANODES IN A GAS-FLOW G-M COUNTER. James F. Becker and Jon Bryan (California. Univ., Livermore. Lawrence Radiation Lab.). Mar. 19, 1962. Contract W-7405-eng-48. 18p.

Several factors were determined experimentally which may be of help when replacing loop anodes in gas-flow counters. Anode material, direction of gas flow, and rotation of the anode about its vertical axis have little effect on the performance of the counter. For lowest threshold voltage and longest plateau, the wire diameter should be of the order of 1 mil and the loop diameter approximately one-half the diameter of the counting chamber. When the loop is moved from a vertical position, the counter efficiency goes down and any departure from a circular shape tends to shorten the plateau. (auth)

**11014** (USNRDL-TR-604) A METHOD OF COMPENSATING FOR TEMPERATURE-DEPENDENCE OF A REMOTE AREA GAMMA MONITORING SYSTEM. P. A. Covey (Naval Radiological Defense Lab., San Francisco). Nov. 27, 1962. 14p.

A remote area gamma radiation monitoring system known as RAMS II, was found to be so temperature-dependent that diurnal variations produced intolerably large output variations. Addition of a thermistor-resistor combination in the cathode circuit of the electrometer tube successfully compensated for temperature effects. The response of the modified system is constant within ±10% between 30 and 80°F, as opposed to an original factor-of-3 variation over this temperature range. (auth)

**11015** A PRESSURE IONIZATION CHAMBER FOR $\gamma$-RADIATION MEASUREMENTS. Bernhard Mengelkamp A E G Mitt., 52: 113-15(1962). (In German)

For the industrial $\gamma$ radiation, a detector was constructed that converts the thickness and density-dependent $\gamma$ radiation directly into an electric current. The Ar-filled tube responds readily to small radiation differences and is able to measure small variations in thickness or density. A definite proportionality factor exists between the saturation current, $I_k$ in amp, and dosage rate, D in Mr/hr, so that $I_k = K_k \cdot D$, where $K_k$ is the chamber constant. Characteristics values of the ionization chamber and specifications for its construction, size, material, and chamber constant, are given. (P.C.H.)

**11016** AN ELECTROMETER AMPLIFIER. Harald Velde. A E G Mitt., 52: 123-5(1962). (In German)

For industrial thickness measurements with $\gamma$ radiation from radioisotopes, an extremely sensitive amplifier, which responds to currents as low as $10^{-12}$ amp, was constructed. The amplifier is very reliable, has small zero-point drift, is sturdy in construction, and draws as little current as possible. A transistorized amplifier with an electron tube pre-amplifier were used for low-drift. To obtain favorable matching conditions for the transistor and high input resistance of the input current not working on the feedback principle, the pre-amplifier was constructed as a cathode follower. The countercurrent resistance was $10^{10}$ to $5 \times 10^{12}$ Ω, and the voltage drift was only 10 to 30 mv. The temperature dependence was very low (about 0.1% per 1°C), current drift was $10^{-14}$ amp, and accuracy of the grid current of $10^{-14}$ amp was about ±1%. (P.C.H.)

**11017** STACK GAS BETA MONITOR. William H. Ray (General Atomic Division, General Dynamics Corp., San Diego, Calif.). Am. Ind. Hyg. Assoc. J., 23: 496-502(Nov.-Dec. 1962).

A large-area, flat-plate counter was designed to obtain a sensitivity of $10^{-7}$ μC/cc to radioactive gases in a reasonably small volume of sample. The counter operates in the proportional mode on its beta plateau and is relatively insensitive to background gamma radiation. Incremental volumes of gas sample at appreciable distances within the beta range are subtended with relatively large solid angles. An electrostatic precipitator was devised to monitor radioactive particulates that may penetrate an absolute filter. The sensitivity is greater than is needed to evaluate noble gas release. Count rate may be recorded continuously while collecting and concentrating the contaminants. (auth)

**11018** A NEW APPARATUS FOR THE COMPLETE SPHERICAL CHECKING OF RADIATION LEAKAGE FROM DIAGNOSTIC X-RAY TUBES. M. J. Butler (Mullard Radio Valve Co. Ltd., Surrey, Eng.). Brit. J. Radiol., 36: 68-71 (Jan. 1963).

An apparatus was developed that will make a complete survey, automatically, in 12 min, and incorporates 50 Geiger-Müller tubes of special design. Directions in which the leakage exceeds a pre-set level are indicated by lamps and it is a simple matter to take measurements in these directions. Routine leakage testing of x-ray tubes is, therefore, possible. Use of the method is also valuable in design work, permitting reduction in the leakage to levels well below the international maximum without the large weight increase that would result from increasing the thickness of protective materials in an indiscriminate manner. (P.C.H.)

**11019** NUCLEAR INSTRUMENTATION. NO. 12. Bull. Inform. Sci. Tech. (Paris), No. 61, 3-34(May 1962). (In French)

In the first part of the review on nuclear instrumentation the rules adopted by the CEA for transistorized nuclear electronics and the mechanical standards for transistorized devices are tabulated. The second part gives the design and performance of new instruments developed by the CEA. The topics discussed are amplifiers and preamplifiers, standardized functional elements, counting devices, and apparatus for personnel protection. (J.S.R.)

**11020** WHY A RING COUNTER—WHY NOT A BINARY? John Durio (Collins Radio Co., Newport Beach, Calif.). Electronics, 36: No. 4, 44-6(Jan. 25, 1963).

The binary counter has fewer components for a given count and is in fashionable use, but it is not always the best circuit for the job. The advantages of the ring counter are: economical power consumption rate, which could be a major factor in a limited power supply such as a space satellite; provision for simplified decimal readout; high power outputs without auxiliary transistors; and freedom from serious counting errors when noise spikes add false triggers. Counting problems and their solutions through the use of

ring counters are discussed. Operational data and circuit diagrams are presented. (H.G.G.)

**11021** NOVEL COINCIDENCE TECHNIQUE FOR TRANSISTOR DECADE COUNTER. Pavan K. Malhotra and Ram Parshad (National Physical Lab., New Delhi, India). Electronics, 36: No. 7, 71-2(Feb. 15, 1963).

A new coincidence technique for achieving decade counting in transistor circuits was described. Count can be advanced in one step or more, at any stage in application of input triggers, and the decade counter can be as fast as the unmodified binary. The method had straightforward application to vacuum-tube circuits where sufficiently high voltages were available for lighting neon lamps. With high-voltage transistors, this method of interpolation should become useful in transistor counters. (C.E.S.)

**11022** THE DESIGN OF A VERY STABLE HIGH VOLTAGE SUPPLY FOR SCINTILLATION COUNTERS. Ming-tao T'ang (M. D. Tang), Yen Chang, and Chi-p'eng Ch'ien. Ho Tzu K'o Hsueh, 3: No. 3, 43-50(July 1961). (In Chinese)

The design and the circuit of a very-high voltage source with steady flow for correcting the unstable local power line are shown. The characteristics are: an incoming a-c current of 105 to 125 v, 60 cycles/sec, and 100 w; an output voltage of 500 to 1500 v d-c (controlled by R18), and 5 ma; positive and negative poles; voltage regulating rate of 0.013% per 10-v change of incoming power (110 v); and a drift voltage of <0.12% per 8-hr period. (OID)

**11023** ADIABATIC MICROCALORIMETER WITH AUTOMATIC CONTROL FOR THE MEASUREMENT OF RADIOACTIVITY. [PART] I. A. Sanielevici and J. Nagl (International Atomic Energy Agency, Vienna). Intern. J. Appl. Radiation Isotopes, 13: 539-46(Oct. 1962). (In French)

A microcalorimeter of the adiabatic type with a new automatic control system for the measurement of energy released by radioactive sources is described. Measurement of the activity of a $Ra^{226}$ needle is given (4.08 mc ± 1 per cent) as an example; the value independently obtained by comparison with an international Hönigschmidt standard was 4.12 mc. A second, improved version of the microcalorimeter is under construction in order to substantially increase the sensitivity. (auth)

**11024** THE PERIODIC INTEGRATOR: AN INSTRUMENT FOR RECORDING RAPID VARIATIONS OF COUNTING RATE. I. Mannelli and L. Donato (Università Pisa, Italy). Intern. J. Appl. Radiation Isotopes, 13: 582-3(Oct. 1962). (TID-16327). (In English)

An instrument was developed, by modifying a commercial ratemeter, which provides direct, undamped records of radiocardiography changes. The instrument is referred to as periodic integrator. The principle of operation is outlined. (P.C.H.)

**11025** MASS SPECTROMETRIC INVESTIGATION OF THE KINETICS OF THE DISSOCIATION OF ETHYL HALOGENIDES IN SELF-QUENCHING GEIGER-MUELLER TUBES. I. Zlotowski and H. Wincel (Univ. of Warsaw). Isotopen Tech., 2: 300-2(1962). (In German)

Studies show the effect of the electrode surface as well as the qualitative and quantitative composition of the decay products of the quenching gas absorbed on this surface on the lifetime of G-M tubes. (tr-auth)

**11026** IONIZATION CHAMBERS WITH ALTERNATING VOLTAGE FEED. G. Schuetz (VEB Vakutronik, Dresden). Isotopen Tech., 2: 279-80(Sept. 1962). (In German)

The application of alternating current to the feed of differential ionization chambers in surface measurement devices was discussed. This permits the saving of expensive or unstable construction units of amplifiers such as vibrating condensers or choppers. The necessity of higher beam activities is a disadvantage. (tr-auth)

**11027** A FLOW-THROUGH METHOD FOR SCINTILLATION COUNTING OF CARBON-14 AND TRITIUM IN GAS-LIQUID CHROMATOGRAPHIC EFFLUENTS. Arthur Karmen, Irmgarde McCaffrey, and Robert L. Bowman (National Heart Inst., Bethesda, Md.). J. Lipid Res., 3: 372-7(July 1962).

A method for radioassay of gas-liquid chromatographic effluents by scintillation counting is described. A cartridge filled with anthracene crystals is used as a flow-through radiation detector. Upon leaving the column, the effluent is passed over hot copper oxide, which converts the organic materials to $CO_2$ and water. If tritium is to be counted, the water is reacted with hot iron to release H and tritium gases. The effluent is then passed through the anthracene cartridge. The counting rate of the cartridge is monitored continuously during the analysis by a highly efficient, low-background scintillation counter to yield a record of eluted radioactivity that resembles the conventional mass detector record. The detector is simply constructed, easily maintained, and insensitive to changes in gas composition but highly sensitive to radiation. High efficiency (more than 70% for $C^{14}$ and 20% for tritium) is coupled with low background counting rates (~15 cpm at $C^{14}$ settings, 50 cpm at tritium settings). The counting rate returns to the low background rate following the detection of a labeled compound. (H.H.D.)

**11028** MATHEMATICAL REPRESENTATION FOR WALD'S COMPARTMENT THEORY. Donald L. Bentley (Colorado State Univ., Fort Collins). J. Opt. Soc. Am., 53: 287-92(Feb. 1963).

G. Wald has suggested a compartment theory for the function of rods in the human retina that corresponds mathematically to that of the Geiger-Müller counter. A discussion is given as to how the compartment theory fits various models for Geiger-Müller counters. Numerical examples are given to illustrate how the mathematical models can be compared with observed threshold curves. A method is also presented for mathematically extending Wald's compartment theory to compartments having structures positioned in a manner similar to the Sjöstrand membranes. Suggestions for further research are presented. (auth)

**11029** RADIOMETRY OF GRANULES OF ACTIVATED YTTRIUM. N. G. Morozova and F. M. Lyass (Vernadskii Inst. of Geochemistry and Inorganic Chemistry, USSR and Burdenko Inst. of Neurosurgery, USSR). Med. Radiol., 7: No. 12, 59-61(Dec. 1962). (In Russian)

A method for determining the activity of granules of $Y^{90}$ with the aid of a redesigned gamma-dosimeter is described. (P.C.H.)

**11030** OXALIC ACID: THE ONLY AQUEOUS DOSIMETER FOR IN-PILE USE. Ivan Draganić (Boris Kidrich Inst. of Nuclear Sciences, Vinca, Yugoslavia). Nucleonics, 21: No. 2, 33-5(Feb. 1963).

The oxalic acid dosimeter has many advantages compared with existing chemical dosimeters. The dose range and the upper limit that can be measured are considerably greater and permit measurements during longer irradiations or at very high dose rates. The dosimeter was not made radioactive by neutrons, making it suitable for in-pile measurements. The system is neither sensitive to impurities nor photosensitive. Analytical-grade oxalic acid was used with no further purification. The pH effect is

negligible under the conditions of application. Although $CO_2$ is the main product of radiolysis of the oxalic acid solution, quantitative gas determination was not sufficiently simple and fast as a dosimetric technique. The amount of decomposed acid was determined as the concentration difference between irradiated and unirradiated samples. The analytical methods given were very precise since the concentration difference may be very small. Dosimetry technique was included as well as a table for suitable concentrations of oxalic acid. The dose can be calculated irrespective of the change in concentration with the equation included. (C.E.S.)

**11031** HIGH-LEVEL LINEAR 0.1 μSEC. GATE CIRCUIT FOR PULSE-HEIGHT ANALYZERS. Ryszard Bayer. Nukleonika, 7: 592-4(1962). (In English)

A linear transmission gate for use in pulse-height analyzers is described. The gate is suitable for positive pulses of 0.1 μsec duration or more and is linear over a range from 0.1 to 100 v. The gate transmits pulses as short as 0.1 μsec with amplifying factor of about 0.9. (P.C.H.)

**11032** A NONOVERLOADING DOUBLE DIFFERENTIATING PULSE AMPLIFIER FOR SCINTILLATION SPECTROSCOPY. Tomasz Goworek (Marie Curie Sklodowska Univ., Lublin (City)). Nukleonika, 7: 649-54(1962). (In English)

A nonoverloading pulse amplifier with improved characteristics is described. In the first feedback group d-c coupling is introduced. In the second very low grid leak resistor of the last tube is driven by totem-pole stage, which assures the high feedback factor. By use of the amplifier low energy lines in the presence of strong (>100 000/sec) hard gamma, background may be analyzed. (auth)

**11033** FAST-SLOW COINCIDENCE CIRCUIT WITH TIME TO PULSE-HEIGHT CONVERTER FOR A NANOSECOND RANGE. Eugeniusz Bożek, Andrzej Z. Hrynkiewicz, Tadeusz Walczak and Grzegorz Zapalski (Inst. of Nuclear Physics, Krakow and Jagellonian Univ., Krakow). Nukleonika, 7: 669-79(1962). (In English)

Some aspects of the operation of the Fischer-Marshall type coincidence circuit modified to a time pulse-height converter are discussed. Examples of its application to nuclear spectroscopy are presented. (auth)

**11034** SIMPLE ISODOSE NEUTRON DETECTOR. Kh. D. Androsenko and G. N. Smirenkin. Pribory i Tekhn. Eksperim., No. 5, 64-71(Sept.-Oct. 1962). (In Russian)

The performance of an assembly consisting of a slow neutron detector placed in an attenuating medium and acting as the transducer of a neutron isodose dosimeter was analyzed. It is shown that for a given paraffin sheath thickness on the $BF_3$ counter the energy dependence of the dose curve between $10^{-2}$ to $10^7$ ev does not exceed 50%. For expanded spectra the order of error is considerably smaller. The performance of detectors with cylindrical and spherical casings was studied, and it was found that the detectors possess high sensitivity for doses of $10^{-3}$ to $10^2$ r with practically no response to γ rays. (tr-auth)

**11035** IONIZATION CHAMBER FOR MEASURING ENERGIES OF FAST NEUTRONS. A. Adam, P. Khrashko, and P. Kvittner (Central Scientific Research Inst. of Physics, Academy of Sciences, Hungary). Pribory i Tekhn. Eksperim., No. 5, 72-6(Sept.-Oct. 1962). (In Russian)

A proton recoil ionization chamber filled with argon and hydrogen mixtures is described. The pulse spectra appearing in neutron bombardment at 2.1, 2.25, 2.5, and 5 Mev were determined. The resolving power at 3 Mev is ±6%. The developed calculations and experimental data were not in agreement due to neutron energy losses on the walls and construction materials. An expression was developed for the amplitude spectra. The formula was verified at 2 to 3 Mev. (tr-auth)

**11036** DELAY SYSTEM USING MAGNETOSTRICTION LINES FOR NEUTRON TIME-OF-FLIGHT SPECTROSCOPY. A. E. Golovin, M. G. Zemlyanov, A. P. Tsitovich, and N. A. Chernoplekov (Inst. of Nuclear Energy, Academy of Sciences, USSR). Pribory i Tekhn. Eksperim., No. 5, 77-9(Sept.-Oct. 1962). (In Russian)

A delay system using magnetostriction lines improved the neutron spectrometer time-of-flight resolving time by a factor of 2.5. The system was developed for use with a spectrometer system for measuring cold inelastic neutron scattering. (tr-auth)

**11037** APPLICATION OF SPARKS IN THE SCINTILLATION TECHNIQUES. L. Ozhdyan, V. S. Pantuev, and M. N. Khachaturyan (Joint Inst. for Nuclear Research, Dubna, USSR). Pribory i Tekhn. Eksperim., No. 5, 80-3(Sept.-Oct. 1962). (In Russian)

A method of fast alignment and control for a scintillation device performing under heavy load in the nanosecond range was described. High-speed light pulses produced by a spark are supplied simultaneously to a large number of counters, thus imitating charged particle passage in a counter. (R.V.J.)

**11038** FORMATION OF DISCHARGE IN A SPARK CHAMBER ALONG THE PARTICLE TRACK. A. A. Tyapkin and Chu-Lien Tsou. Pribory i Tekhn. Eksperim., No. 5, 84-7(Sept.-Oct. 1962). (In Russian)

The construction of a spark chamber with a thin aluminum foil electrode and a pulsed supply system is described. The conditions producing discharge along the ionizing particle tracks inclined towards the field are found. (tr-auth)

**11039** URANIUM SALTS IN NUCLEAR EMULSIONS SENSITIVE TO MINIMUM IONIZATION. T. A. Romanova and L. D. Chikildina (Inst. of Physics, Academy of Sciences, USSR). Pribory i Tekhn. Eksperim., No. 5, 88-93(Sept.-Oct. 1962). (In Russian)

Uranium fission fragments were recorded using 200 to 250 μ plates of NIKFI-R saturated with uranyl acetate. The developed loading and exposure methods permitted handling of $3 \times 10^{18}$ to $4 \times 10^{18}$ U nuclei per $cm^2$. Moreover, a complete and uniform exposure with good sensitivity and particle discrimination was achieved for the total depth of the emulsion. (tr-auth)

**11040** EFFICIENCY OF A RADIATION COUNTER SUBMERGED IN AN ACTIVE ZONE. G. I. Kosourov (Naval Hydrophysical Inst., Academy of Sciences, USSR). Pribory i Tekhn. Eksperim., No. 5, 95-7(Sept.-Oct. 1962). (In Russian)

The dimensions of the effective volume of a counter submerged in an active medium is identical to the volume of a cylinder with a base equal in all directions to the cross section of effective counter volume and in height to the length of the free radiation path in the medium. The additions introduced by scattered radiation are evaluated and the effects of a plane interface are discussed. (tr-auth)

**11041** STATISTICAL PROCESSES IN SCINTILLATION COUNTERS. D. G. Fleishman (Inst. of Evolution Physiology, Academy of Sciences, USSR). Pribory i Tekhn. Eksperim., No. 5, 98-102(Sept.-Oct. 1962). (In Russian)

The statistical ratio of the photoeffect and secondary electron emission is evaluated. Studies of pulse amplitude distribution from single electrons emitted by a photocath-

ode indicate that the second emission statistics for some diodes are in good agreement with Poisson's law. The intrinsic efficiencies (the mean number of photoelectrons reaching the first diode per unit of scattered energy in a scintillator) of counters with NaI(Tl) crystal and liquid scintillators were determined on the basis of statistical data and by direct comparison of mean pulse amplitudes for single electrons and ionizing particles of a given energy. For the FEU-1B the magnitudes are 3900 and 555 e/Mev. (tr-auth)

**11042** APPLICATIONS OF DATA FOR DESCRIBING CHARACTERISTICS OF RADIOMETRIC APPARATUS. V. V. Artem'ev (Archeological Inst., Leningrad). Pribory i Tekhn. Eksperim., No. 5, 102-3(Sept.-Oct. 1962). (In Russian)

Information expressed in binary units was used for describing measurements of radioactivity. The decay rate of the specimen n and background $n_f$ for the time T offers the information $I = \log (V\bar{n} - V\bar{n}_f) + \frac{1}{2} \log T$. The magnitude $N = \log (V\bar{n} - V\bar{n}_f)$ may be used as a criterion of the efficiency of the radiometric apparatus. (tr-auth)

**11043** PULSE AMPLITUDE ANALYZER WITH PERIODIC MEMORY DEVICE. R. G. Ofengenden and O. M. Rozental (Inst. of Physics, Academy of Sciences, Ukrainian SSR). Pribory i Tekhn. Eksperim., No. 5, 113-17(Sept.-Oct. 1962). (In Russian)

A design is given of a multichannel amplitude analyzer equipped with a periodic magnetic-drum memory device. The design can be expanded and used as a multidimensional analyzer. (tr-auth)

**11044** SCINTILLATION COUNTER WITH $CaF_2$ CRYSTAL. Yu. Ya. Stavisskii and A. V. Shapar. Pribory i Tekhn. Eksperim., No. 5, 177-8(Sept.-Oct. 1962). (In Russian)

The performance of a scintillation counter with natural (l = 2 cm) and prepared ($\phi$ = 3.5 cm and h = 3 cm) $CaF_2$ crystals, capable of recording $\gamma$ rays in the presence of a large neutron flux, is discussed. (R.V.J.)

**11045** RESPONSE CHARACTERISTICS OF SEMICONDUCTOR DETECTORS. N. Vylkov (Inst. of Nuclear Physics, Bucharest). Rev. Phys., Acad. Rep. Populaire Roumaine, 7: 397-402(1962). (In Russian)

The characteristics and response time of semiconductor detectors are analyzed, and an improved amplifying scheme based on slow and fast coincidence, in which the signal is sent simultaneously along two channels (one with a slow narrow emission band and low noise and the other with fast and efficient response), is suggested. The scheme is similar to that used in scintillation detectors except that with semiconductor detectors the same signal is used for the slow and fast channels. (R.V.J.)

**11046** INERTIALESS CONTRAST INTENSIFICATION OF SCINTIGRAPHS. Rudolf Praeg (Siemens-Reiniger-Werke A. G., Erlangen, Ger.). Strahlentherapie, 119: 569-83(Dec. 1962). (In German)

Slightly hypoactive centers or areas with small differences in activity in a scintigram can be resolved only, if the image contrast is increased artificially. A method for contrast intensification, using directly the single pulses from a detector, is reported. Only those pulses are registered, which have a shorter time difference from the preceding pulse than a preselected period of time. This selection of the pulses permits especially an elimination of noise as well as of a given intensity level with linear or non-linear representation of the remaining radiation intensity. An instrument developed using this principle for function and manipulation is described. The type of operation is demonstrated by using examples. (auth)

**11047** THE EFFECT OF OXYGEN AND WATER VAPOR ADDITIONS ON THE ION MOBILITY AND ELECTRON ACCUMULATION PROBABILITY IN NITROGEN. W. Huebner and C. Klett (Physikalisch-Technische Bundesanstalt, Braunschweig, Ger.). Z. Naturforsch., 17a: 763-71(Sept. 1962). (In German)

In an ionization chamber filled with nitrogen at 1 atm, pulses of positive and negative charge carriers were produced by x-ray beam pulses. Oxygen (up to 2.5 vol %) and/or water (up to 2.3 vol %) were added to the nitrogen. The ion mobilities and electron accumulation probabilities were determined from the oscillograph. The probabilities were strongly reduced by water vapor impurities. The electron accumulation probability increases with the oxygen concentration. In nitrogen with 2.3 vol % water vapor, it is approximately 10 times larger than in dry nitrogen. Water vapor alone in nitrogen appears to accumulate no electrons. (tr-auth)

**11048** INVESTIGATION OF PARALLEL WORK OF CONTROLLED SPARK GAPS. S. L. Zaients, G. S. Kichaeva, and P. I. Shkuropat (Kalinin Polytechnic Inst., Leningrad). Zh. Tekhn. Fiz., 32: 1386-91(Nov. 1962). (In Russian)

Parallel operation of several controlled spark discharge devices was investigated, and the efficiency of parallel operations was varified. (tr-auth)

**11049** ELEKTRONNYE SISTEMY MNOGOKANAL'NYKH SPEKTROMETROV YADERNYKH CHASTITS. (Electronic Systems for Nuclear Multichannel Spectrometers). A. N. Sinaev. Moscow, Gosatomizdat, 1962. 96p.

A survey is given of nuclear spectrometers. The construction of various spectrometer sections is discussed. The book was designed for scientists, engineers, and technicians using electronic equipment in nuclear physics, geology, medicine, and other fields. (R.V.J.)

# ISOTOPE SEPARATION

*Refer also to abstract 10508.*

**11050** (BNL-6697) MILKING SYSTEMS—STATUS OF THE ART. Margaret W. Greene, Robert F. Doering, and Manny Hillman (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT(30-2)-Gen-16]. 24p.

A review is presented of milking systems for separating a desired radioisotope from its parent and other contaminants. Milking systems are considered for the separation of the following radioisotopes: $Zr^{95}$ from $Nb^{95}$, $I^{132}$ from $Te^{132}$, $La^{140}$ from $Ba^{140}$, $Ba^{137}$ from $Cs^{137}$, $Y^{90}$ from $Sr^{90}$, $Tc^{99m}$ from $Mo^{99}$, $Ga^{68}$ from $Ge^{68}$, $Al^{28}$ from $Mg^{28}$, etc. (D.L.C.)

**11051** (TID-15343) EVALUATION OF THE PERFORMANCE OF THERMAL DIFFUSION COLUMNS. Edward Von Halle (Oak Ridge Gaseous Diffusion Plant, Tenn.) [nd]. Contract [W-7405-eng-26]. 4p.

Three thermal diffusion columns of the hot-wire type were employed to test their effectiveness for the separation of the isotopes of xenon. A correlation and analysis were made utilizing both the steady state and transient data obtained from these columns separating a multicomponent mixture of xenon isotopes. The general procedures for analyzing both steady state and transient experimental data on the separation of multicomponent isotopic mixtures are indicated. The observed performance of these columns was compared with that predicted by theory. (auth)

**11052** (TID-15348) THE SEPARATION OF ISOTOPES OF ELEMENTS OTHER THAN URANIUM BY THE GASEOUS DIFFUSION PROCESS. S. A. Levin (Oak Ridge Gaseous Diffusion Plant, Tenn.). [nd]. Contract W-7405-eng-26. 27p.

Preliminary studies were made of the feasibility of using the gaseous diffusion process for the production of enriched isotopes of certain specific elements which are of interest in various phases of the United States' nuclear program. The results of these studies indicate the gaseous diffusion process is probably the most practicable method of separating the isotopes of tungsten, molybdenum, and xenon to produce materials with the desired characteristics. In each of these cases one is confronted with the problem of separating the isotopes of a multicomponent mixture: in the case of tungsten the desired isotope, $W^{184}$, is a middle isotope in the naturally occurring mixture. Special modes of operation are required in order to enrich a mixture with respect to a middle isotope. Since all of the considerations which apply to the separation of the various isotopes mentioned above are included in a discussion of the tungsten problem, only the specific problem of enriching the desired isotope of tungsten is discussed. (auth)

**11053** (TID-15764) FLOW AND SEPARATION IN A LONG COUNTERCURRENT GAS CENTRIFUGE. A. S. Berman (Oak Ridge Gaseous Diffusion Plant, Tenn.). May 4, 1962. Contract [W-7405-Eng-26]. 25p.

A theory is developed for the separation of isotopes in a long countercurrent gas centrifuge. With the selection of a suitably simplified hydrodynamic model, velocity profiles are obtained which permit the evaluation of the integrals arising in the separation theory. The treatment provides estimates of the axial variation of light component composition in each of the countercurrent streams in the centrifuge. For a particular set of conditions, the present results are compared with those obtained from the theory previously presented by Cohen. Both theories yield virtually identical results for moderate peripheral velocities and low ratios of product to internal flow. At higher ratios of product to internal flow, the predictions of the present treatment depart from those of Cohen's theory. Enrichments predicted by the present theory are compared with some of Groth's experimental results. The agreement is satisfactory except at intermediate feed rates where the experimental results are significantly higher than those obtained from the theory. (auth)

**11054** (UVA-279-63U) COUNTERCURRENT FLOW IN A SEMI-INFINITE GAS CENTRIFUGE. PRELIMINARY RESULTS. Hermon M. Parker and Thomas T. Mayo, IV (Virginia. Univ., Charlottesville. Research Labs. for Engineering Sciences). Jan. 1963. Contract AT(40-1)-1779. 53p. (EP-4422-279-63U).

Preliminary results on optimum and practical countercurrent flow in gas ultracentrifuges are presented. An internal flow problem for countercurrent centrifuges was solved for a semi-infinite-length case. The lowest mode results indicate that at values of the speed parameter above about 2.5, decay lengths are higher than those calculated in an isothermal version of the problem. (J.R.D.)

**11055** (UVA-280-63U) COUNTERCURRENT FLOW IN A SEMI-INFINITE GAS CENTRIFUGE: MIXED THERMAL BOUNDARY CONDITION. Hermon (Herman) M. Parker (Virginia. Univ., Charlottesville. Research Labs. for Engineering Sciences). Jan. 1963. Contract [AT(40-1)-1799]. 26p. (EP-4422-280-63U).

Results of calculations are presented which provide an insight into the nature of the missing (two-stream) mode as apparent in an analysis of the previously reported insulated wall case. A mixed, thermal boundary condition is used which enables a continuous transition from the constant temperature wall case to the insulated wall case. It is found that the lowest constant temperature mode transforms smoothly, in the insulated wall limit, to a nondecaying ($\alpha \rightarrow 0$) mode which strongly violates any reasonable linearization criteria and which must be regarded as a nonphysically realizable solution to the problem. The next higher constant temperature mode transforms smoothly into the three-stream insulated wall mode previously found. (J.R.D.)

**11056** (CEA-tr-A-1159) PROCÉDÉ DE FABRICATION DE L'EAU LOURDE PAR ELECTROLYSE EN CASCADE. (Process for Production of Heavy Water by Electrolysis in Cascade). F. Uhde. Translated into French by R. Carbonnier from German Patent 1,058,479. Apr. 28, 1962. 12p.

A process for the production of $D_2O$ by cascade electrolysis is given. In the process, the electrolyte at the first stage of the cascade is a preconcentrate with a deuterium concentration such that the gas produced at the cathode during the electrolysis has a deuterium concentration corresponding in general to that of ordinary water. The cathode gas is liquefied separately, and the deuterium is separated by fractional distillation at each cascade stage. Part of the electrolysis is done under pressure between 20 and 60 atm. (J.S.R.)

**11057** GAS CHROMATOGRAPHIC SEPARATION OF HYDROGEN ISOTOPES ON ACTIVATED ALUMINA.

M. Venugopalan and K. O. Kutschke (National Research Council, Ottawa). Can. J. Chem., 41: 548-9(Feb. 1963). (NRC-7096)

Columns of strongly activated reagent-grade alumina (apparently iron-free) were used for the chromatographic separation of $D_2$, HD, and $H_2$. A typical chromatogram of micromole quantities of the hydrogen isotope mixture shows the $H_2$, HD, and $D_2$ peaks at 13.5, 17.9, and 28.2 minutes, respectively, for the column and flow conditions used. The slopes of the straight-line portions of the plots were 0.254, 0.267, and 0.238 (arbitrary units) for $H_2$, HD, and $D_2$, respectively. (P.C.H.)

**11058** A NEW PROCEDURE FOR THE PREPARATION OF HEAVY WATER BY ISOTOPIC EXCHANGE. E. Roth (Centre d'Études Nucléaires, Saclay, France). Energie Nucl., 4: 332-42(Sept.-Oct. 1962). (In French)

A new method for the preparation of heavy water is based on the isotopic exchange of gaseous ammonia and the hydrogen contained in a synthetic gas. This exchange should be catalyzed by potassium amide in liquid ammonia solution. After a review of the principles of the preparation of heavy water by isotopic exchange, the difficulties in setting up $NH_3-H_2$ exchange are discussed, and the methods for avoiding these difficulties are described. The advantages of this procedure with respect to other procedures are shown. (tr-auth)

**11059** THE SEPARATION TUBE. XXV. CONCENTRATION DISTRIBUTION OF POLYNARY ISOTOPIC MIXTURES IN A THERMODIFFUSION SEPARATION INSTALLATION. Klaus Clusius and Eva Varde (University of Geneva). Helv. Chim. Acta, 45: 2273-84(1962). (In German)

The general reference scheme between the concentrations or mole fractions, $\gamma$, of isotopes in a separation tube installation with length coordinates, $\zeta$, were established so that the thermodiffusion fraction in the first approximation was made proportional to the difference of the mass number of two isotopes or isotopic molecules. If the composition of the natural gas mixture is maintained at the zero point of the installation, the distribution of the isotopes of an element along the separation installation can be obtained immediately from the $\gamma$-$\zeta$ diagram. The corresponding curves for this "open" procedure were reported for Kr, Xe, S, and Se. The following general conclusions were made. The distribution function of the isotopic concentrations has, in general, no symmetry properties. In agreement with experimental results, only both "boundary isotopes" of a pleiad, that is, the largest nuclide and the one with the smallest mass number, can be obtained pure directly. "Middle isotopes" pass continually through maxima, which in application of the first approximation lie exactly in the place where the average mass number $\tilde{m} = \Sigma_{k=1}^{n} m_k \gamma_k$ is identical with the mass number of the isotope examined $m_i$. Two frequency curves always cross each other only at one point. The $\gamma$-$\zeta$ diagram is the same for all compounds of an element, for example, $H_2S$, $D_2S$, $C^{12}O^{16}S$, $SO_2^{16}$, $SF_6$, so long as one considers molecules which except for pure elements contain only one atom of the element concerned. By the addition of an auxiliary gas, completely new ratios arise since the thermodiffusion factors were then concentration dependent. (tr-auth)

**11060** ISOTOPE SEPARATION BY GASEOUS DIFFUSION–A REVIEW. Ingemar Eriksson and Mårten Martenson (Kungiliga Tekniska Högskola, Stockholm). Svensk Kem. Tidskr., 74: 609-17(1962). (In Swedish)

The Swedish work on isotope separation by means of gaseous diffusion is reviewed. The work was conducted by Ole Lamm and carried out in 1946 to 61 (with interruption during 1952 to 54). The work was mainly exploratory and can be divided into four parts: basic theoretical studies, barrier development studies, uranium hexafluoride technology, and the development of small laboratory cascades. Some characteristic properties of the gaseous diffusion process are discussed in this review and some of the experimental results obtained are briefly described. (auth)

**11061** GAS DYNAMIC CALCULATION OF NOZZLE SEPARATION. F. Zigan (Technische Hochschule, Karlsruhe, Ger.). Z. Naturforsch., 17a: 772-8(Sept. 1962). (In German)

In an expanding ultrasonic flow a partial spatial separation of various heavy gases occurs. A study was made to determine what separation effects are given in an ideal isentropic expansion of the beam appearing as a result of the pressure diffusion under neglect of thermodiffusion and concentration diffusion in the case of argon isotopes. Of special interest was the effect of an ultraexpansion and a mechanical reversal of the stream. The flow surface of various flow types was calculated by the characteristic method. With the theoretically obtained flow surface distribution, the separation effect to be expected was determined. The essential features of the separation effect were represented directly from theory. Systematic deviations between theory and experiment appear at small intake pressures in which the effects of friction and of the transition to molecular ratios are noticeable. (tr-auth)

**11062** SEPARATION NOZZLE METHOD WITH LIGHT AUXILIARY GAS. E. W. Becker, K. Bier, and W. Bier (Technische Hochschule, Karlsruhe, Ger.). Z. Naturforsch., 17a: 778-85(Sept. 1962). (In German)

In the separation nozzle method, the current density of the separating pressure diffusion current in a heavy isotopic mixture was increased by the addition of a light gas. In the case of argon isotopes an increase of the elementary effect of the separation by a factor of 1.7 appeared through the addition of about 900 mol % He at the same throughput and by-pass ratio of the argon. Although the coprocessing of the light gas in a separation cascade stipulates a supplementary expenditure, the efficiency of the separation method is improved by the addition of a light gas. In argon isotopes with a helium addition of 400 mol %, the specific feed volume was cut to $\frac{1}{4}$, the specific slit length to $\frac{1}{4}$, and the specific compression work to $\frac{3}{4}$ of the values for pure argon. (tr-auth)

# MATHEMATICS AND COMPUTERS

**11063** (BNL-757) CONCERNING POLYNOMIALS ENCOUNTERED IN THE STUDY OF THE DISTRIBUTION FUNCTION OF SPACINGS. L. D. Favro, P. B. Kahn, and M. L. Mehta (Brookhaven National Lab., Upton, N. Y.). Sept. 1962. Contract [AT-30-2-GEN-16]. 6p. (BNL-T-280)

An attempt is made to improve the upper bound on the cumulative distribution function F(S), of spacings of eigenvalues of a random matrix. In this process some polynomials are encountered, and their properties are discussed. (auth)

**11064** (CERN-62-35) FORMULA TRANSLATION AND COMBINATORIAL SYSTEMS. P. B. Sheridan (European Organization for Nuclear Research, Geneva). Nov. 20, 1962. 18p.

The thesis that every formula translation system is effectively equivalent to a class of combinatorial systems is illustrated. A class of combinatorial systems effecting translation of Mercury AUTOCODE variable expressions into ALGOL 60 arithmetic expressions is presented. An example is included. (M.C.G.)

**11065** (LA-2367(Add.)) THE SOLUTION OF THE GENERAL LEAST SQUARES PROBLEM WITH SPECIAL REFERENCE TO HIGH-SPEED COMPUTERS. Paul McWilliams (Los Alamos Scientific Lab., N. Mex.). Nov. 1, 1962. Contract W-7405-eng-36. 20p.

This report extends and revises LA-2367.

Changes in the Los Alamos non-linear least squares program are outlined. A condensed guide for the data card arrangement is presented. The PAKAG code is written in FORTRAN language for the IBM-7090. The system fits a given function to a given data set. The function to be fitted can be any "well-behaved" mathematical function for which the derivatives exist and for which the data set does not give rise to points of singularity. (M.C.G.)

**11066** (ORNL-3394) CASPER: A GENERALIZED PROGRAM FOR PLOTTING AND SCALING DATA. M. P. Lietzke and R. E. Smith (Oak Ridge National Lab., Tenn.). Jan. 30, 1963. Contract W-7405-eng-26. 32p.

A Fortran subroutine was written to scale floating-point data and generate a magnetic tape to plot it on the Calcomp 570 digital plotter. The routine permits a great deal of flexibility, and may be used with any type of FORTRAN or FAP calling program. A simple calling program was also written to permit the user to read in data from cards and plot it without any additional programming. Both the Fortran and binary decks are available. (auth)

**11067** (ORNL-TM-430) AN IBM-7090 SUBROUTINE PACKAGE FOR MAKING LOGARITHMIC AND SEMILOGARITHMIC GRAPHS USING THE CALCOMP PLOTTER. D. K. Trubey and M. B. Emmett (Oak Ridge National Lab., Tenn.). Dec. 12, 1962. Contract [W-7405-eng-26]. 10p.

An IBM-7090 subroutine package was written to facilitate the plotting of curves and points on logarithmic and semilogarithmic graphs using the CALCOMP plotter. The subroutines accomplish the necessary computations and prepare a magnetic tape for use by the plotter. (auth)

**11068** (TID-15948) A NOTE ON ERGODIC TRANSFORMATIONS. J. R. Blum and D. L. Hanson (Sandia Corp., Albuquerque, N. Mex.). [May 1962]. Contract [AT(29-1)-789]. 5p. (SCDC-2682)

A probability space, $(\Omega, A, P)$, was assumed with T a 1-1 point transformation mapping $\Omega$ onto $\Omega$ which is bimeasurable and measure preserving with respect to A. If T is ergodic, then $\lim_{N \to \infty} \Sigma_{i_1=0}^{N-1} \cdots \Sigma_{i_N=0}^{N-1} P(A_0 T^{i_1} A_1 \cdots T^{i_N} A_N)/N^N = \pi_{i=0}^{N} P(A_i)$. A convergence theorem for measures was proved, and a slight generalization of the equation was obtained as a corollary of the theorem. (M.C.G.)

**11069** (TID-17551) TECHNICAL PROGRESS REPORT. PART I. HIGH-SPEED COMPUTER PROGRAM. PART II. CIRCUIT RESEARCH PROGRAM. PART III. MATHEMATICAL METHODS. PART IV. DATA REDUCTION METHODS. PART V. ILLIAC USE AND OPERATION. PART VI. CONTROL DATA CORPORATION 1604. PART VII. IBM 7090-1401 SYSTEM. PART VIII. INSTRUCTIONAL USE OF THE IBM 7090-1401 SYSTEM. PART IX. GENERAL LABORATORY INFORMATION. (Illinois. Univ., Urbana. Digital Computer Lab.). Sept. 1962. Contract AT(11-1)-415. 52p.

Activities in the high-speed computer program were devoted to computer checkout, core memory development, magnetic drum memory development, and slow circuit development. In other work, experiments were carried out with the purpose of evaluating theoretical methods for calculation of transition times and wave forms of input and output voltages in flip-flop circuits. Work on mathematical methods was devoted to Monte Carlo calculations. Data are included concerning usage of the Iliac, and information on installation and checkout of the IBM 7090-1401 system is given. (J.R.D.)

**11070** (TID-17653) FURTHER STUDIES IN SPEED-INDEPENDENT LOGIC FOR A CONTROL. Report No. 130 (thesis). Robert Earl Swartwout (Illinois. Univ., Urbana. Digital Computer Lab.). Dec. 13, 1962. Contract AT (11-1)-415. 111p.

A design method for the control of a computer arithmetic unit that produces logical configurations that operate as free of malfunctions as possible and that are relatively easy to maintain is discussed. Attempts were made to develop a control design in which all portions of the logic are speed-independent. Four different methods were evaluated. (M.C.G.)

**11071** (TID-17810) TECHNICAL PROGRESS REPORT. PART I. HIGH-SPEED COMPUTER PROGRAM. PART II. CIRCUIT RESEARCH PROGRAM. PART III. SWITCHING THEORY. PART IV. MATHEMATICAL METHODS. PART V. DATA REDUCTION METHODS. PART VI. ILLIAC USE AND OPERATION. PART VII. IBM 7090-1401 SYSTEM. PART VIII. INSTRUCTIONAL USE OF THE IBM 7090-1401 SYSTEM. PART IX. CONTROL DATA CORPORATION 1640. PART X. GENERAL LABORATORY INFORMATION. (Illinois. Univ., Urbana. Digital Computer Lab.). Nov. 1962. Contract AT(11-1)-415. 67p.

The present status of all the computer and mathematical research programs is outlined. (D.L.C.)

**11072** (UCRL-6648-T) ON CLOSED EXTENSIONS OF SECOND ORDER, FORMALLY SELF-ADJOINT UNIFORMLY ELLIPTIC DIFFERENTIAL OPERATORS. R. S. Freeman (California. Univ., Livermore. Lawrence Radiation Lab.). Oct. 12, 1961. Contract W-7405-eng-48. 19p.

Let G be a bounded domain in $E^m (m > 1)$ with $\partial G$ an m-1 dimensional $C^2$ manifold. Let $A = -\Sigma d_j a_{ij} D_i + c$ be a

formally self-adjoint, uniformly elliptic operator with coefficients in $C^2(G)$. Let $D_L(G) = \{u \epsilon W^{1,2}(G)$: (i) $u \epsilon W^{2,2}_{loc}(G)$, (ii) $Au \epsilon L^2(G)$, (iii) $u, u_\nu$ have $L^2$ boundary values$\}$ where $u_\nu = \Sigma_{i,j=1}^{m} a_{ij} D_i u \cos(n, x_j)$, n being the unit normal to $\partial G$. Let L be a bounded operator on $L^2(\partial G)$ and define $D(T_L) = \{u \epsilon D_L(G)$: $\tilde{u}_\nu - L\tilde{u} = 0\}$, u denoting the $L^2$ boundary value of u. For $u \epsilon D(T_L)$ let $T_L u = Au$. Then: Theorem: (i) $T_L$ is a closed linear operator in $L^2(G)$, (ii) $(T_L)^* = T_{L^*}$, (iii) $T_L$ has compact resolvent, (iv) $\sigma(T_L)$ lies in a parabolic region opening to the right. If G is an exterior region then (i), (ii), and (iv) are still true. If G and $\partial G$ are unbounded, then (i) and (ii) are true if L is multiplication by a bounded, measurable function. (auth)

**11073** (UCRL-10491) INTRODUCTION TO PROJECT LOGIC PLANNING. William C. Bagot (California. Univ., Berkeley. Lawrence Radiation Lab.). Oct. 1962. Contract W-7405-eng-48. 16p.

It is noted that over the past several years considerable work was done in developing methods for the management of large-scale projects. A new technique for handling such projects is described that allows for more randomly numbered node points to be used and provides for an exact relation between working time and calendar time. The name PROLOG was given to the method. It was used to schedule operations in connection with the ASTRON and the Bevatron improvement program. Information is included on preparation of the project Logic diagram, determination of project duration, data processing, and PROLOG limitations. (J.R.D.)

**11074** (XDC-61-5-2) SCRAMBLE— FOR SIMULATION OF PERIPHERAL EQUIPMENT ON THE IBM 1401. David S. Latimore (General Electric Co. Aircraft Nuclear Propulsion Dept., Cincinnati). Jan. 1961. Contracts AF33(600)-38062 and AT(11-1)-171. 45p.

SCRAMBLE (Special Consolidated Routine Allowing More Basic Loading Efficiency) is a self-contained program for simulating peripheral equipment on the IBM 1401 computer. The specifications, control cards, operating instructions, memory map, flow diagrams, and assembly listings of the program are given. (D.L.C.)

# METALS, CERAMICS, AND OTHER MATERIALS

## General and Miscellaneous

*Refer also to abstract 12014.*

**11075** (AD-278043) AN INVESTIGATION OF THE CRACK-PROPAGATION RESISTANCE OF HIGH-STRENGTH ALLOYS AND HEAT-RESISTANT ALLOYS. Bimonthly Progress Report No. 9, April 23, 1962–June 23, 1962. W. R. Salzman and J. D. Morrison (Southern Research Inst., Birmingham, Ala.). July 10, 1962. Contract NOw-61-0392-d. 12p.

The tensile properties and crack-propagation properties of 0.050 in.-thick D-14 Nb-alloy sheet were determined at −300 to 1200°F. No brittle-ductile transition was found at temperatures down to −300°F. Very slight evidence of strain aging manifested by increased strength properties and serrated plastic stress-strain curves, was noted at 600 and 1100°F. (auth)

**11076** (AD-278371) IMPROVEMENT OF THE USEFULNESS OF PYROLYTIC GRAPHITE IN ROCKET MOTOR APPLICATIONS. Annual Technical Summary Report No. 2. James D. Batchelor, Edwin F. Ford, and Eugene L. Olcott (Atlantic Research Corp., Alexandria, Va.). June 1962. Contract DA-36-034-ORD-3279. 50p.

Work on the application of pyrolytic graphite in high performance solid propellant motors is described. Studies of the deposition process variables continued with emphasis on methods of improving the microstructure of coatings formed at lower deposition temperatures. A substrate pretreatment consisting of a furane resin impregnation shows promise. Emphasis was placed on the measurement of the erosion rate of nozzles coated with a standard (2000°C) grade of pyrolytic graphite in rocket motor firings. For propellants with flame temperatures of 5600 and 6000°F, the erosion rate was very low. With a 6500°F propellant, erosion increased with increasing motor pressure and reached a rate near 0.5 mil/sec at about 900 psi. This indicates the utility of pyrolytic graphite for solid propellant rocket nozzles. Mechanical design and stress analysis calculations were made; based on these, the utility of segmented nozzle designs was substantiated. (auth)

**11077** (ANL-6644) SUMMARY OF INVESTIGATIONS UPON THE $UO_2$–NaK SLURRY AS A POTENTIAL REACTOR FUEL. R. D. Carlson and E. S. Sowa (Argonne National Lab., Ill.). Nov. 1962. Contract W-31-109-eng-38. 69p.

A summary is given of studies carried out with the $UO_2$–NaK slurry system to ascertain its potential properties as a fuel for advanced reactor systems. Included are the studies of the physical-chemical properties of the slurry, the early loop investigations, in-pile studies, and the exploration of the engineering system behavior of the material. The work was carried out in three different institutions. The Argonne National Laboratory was responsible for the early loop studies and the in-pile work, as well as some phases of the physicochemical behavior. The engineering studies were carried out for ANL by the Mine Safety Appliances Corporation, Callery, Pennsylvania. The physicochemical studies were performed by the Armour Research Foundation, Chicago, Illinois. The studies under the program were relatively modest, but they did serve to demonstrate some of the attractive properties of the material as well as its limitations. Specifically, the dropout behavior was demonstrated in piping and tank systems in both conventional and specially designed systems. Hydraulic characteristics were demonstrated, and it was observed that a 10 vol % slurry was the maximum concentration that could conveniently be handled in conventional engineering systems. In-pile performance of the slurry was demonstrated and it was concluded that slurries do have potential for application in specialized, advanced systems. (auth)

**11078** (ANL-FGF-329) EVALUATION AND ASSEMBLY BY VACUUM BRAZING OF THE SUPERHEATER FUEL PLATES FOR THE BOILING REACTOR EXPERIMENT-V. W. C. Kramer and C. H. Bean (Argonne National Lab., Ill.). Feb. 23, 1961. Contract [W-31-109-eng-38]. 5p. (UAC-6168)

Development of special nondestructive evaluation methods for Borax-V superheat fuel plate quality and special techniques for vacuum brazing these plates into rigid elements is described. The fuel for the superheat region of the reactor is in the form of plates containing a dispersion of $ClO_2$ in austenitic stainless steel clad with similar material. The nondestructive tests were developed to determine the $U^{235}$ distribution, detect surface contamination, and evaluate core-to-clad bonding. (J.R.D.)

**11079** (ANL-FGF-334) THE DIFFUSION OF IRON AND CHROMIUM IN BETA URANIUM. S. J. Rothman, N. L. Peterson, and S. A. Moore (Argonne National Lab., Ill.). May 1, 1962. Contract W-31-109-eng-38. 7p. (UAC-6407)

Measurements of the diffusion of $Fe^{59}$ and $Cr^{51}$ in beta uranium from thin deposited layers are reported. Anomalies in the data were observed which could be explained by anisotropic diffusion in the beta phase. The $D_{Fe} : D_{Cr} : D_{self}$ was found to be 1,900 : 160 : 1 in beta uranium at 750°C, as compared with 120 : 13 : 1 in the gamma phase at 903°C. (D.L.C.)

**11080** (ASD-TDR-62-756) DEVELOPMENT AND TESTING OF TUNGSTEN EMITTERS FOR ION PROPULSION SYSTEMS. J. M. Gerken, R. H. Hiltz, and F. J. Lally (TAPCO. Div. of Thompson Ramo Wooldridge Inc., Cleveland). July 1962. Contract AF33(616)-8297. 59p.

A process is presented for the production of porous W emitter disks with a pore spectrum of 0.7 to 0.9 $\mu$ and a mean pore diameter of 0.8 $\mu$. Studies of joining the emitter disks to refractory metal plenum chamber by electron beam welding were conducted. Work was performed on both W and Nb plenum chambers and in both cases embrittlement was a serious problem. Although difficulties were encountered in successfully welding round emitters into the plenum chamber, sufficient assemblies were prepared for testing. Assemblies successfully withstood 100 hour exposure at 2500°F in a Cs atmosphere. An initial ion efficiency of 98.4% was obtained but owing to poisoning the ion efficiency decreased with increasing time at temperature. (auth)

**11081** (ASD-TR-7-886(Vol.VII)) DEVELOPMENT OF 2400°F FORGING DIE SYSTEM. Interim Technical Progress Report, September 28, 1962–December 27, 1962. H. Nudelman, A. H. Murphy, T. Watmough, and P. R. Gouwens (Illinois Inst. of Tech., Chicago. Armour Research Foundation). Jan. 1963. Contract AF33(600)-42861. 24p.

Activities in a program to evaluate new materials for

use as a 2400°F forging die are reported. Experiments were performed to determine the feasibility of using a viscous protection coating rather than the conventional solid coatings for the refractory metals. A high-temperature BaCl–NaCl heat-treating salt product rectified with C successfully inhibits oxidation loss at 2400°F. The need for immersion does, however, dictate several restrictions on the die design in order to maintain a pool of liquid salt over the susceptible parts of the high-temperature die system. The problem of die component creep at high temperature imposes additional requirements on the compatibility of the various materials used in the die system. Refractory materials such as $TiB_2$, Refrax, and KT SiC remain most promising, with the latter two excelling. Die design again is somewhat restricted in that the stresses imposed must produce die loads largely dominated by compressive stresses. A prototype die system to be used for high-temperature heating studies has been constructed and is described in detail. Heating to 2400°F will be accomplished through electrical resistance heating elements supplemented by gas flame radiation on the die surface. (auth)

**11082** (BBC-113) DEVELOPMENT OF INTERMETALLIC COMPOUNDS FOR VERY HIGH TEMPERATURE APPLICATIONS. Quarterly Progress Report, January 1, 1962 through March 31, 1962. R. M. Paine, A. J. Stonehouse, and W. W. Beaver (Brush Beryllium Co., Cleveland). May 31, 1962. Contract AT(33-3)-20. 30p.

Investigation of the intermediate-temperature behavior of the beryllides, $ZrBe_{13}$ in particular, is discussed. $ZrBe_{13}$ containing 0.35 to 0.45 wt. % aluminum shows excellent oxidation resistance in moist air, as well as in ambient air, in the 1200 to 1700°F temperature range. At very high temperatures (2900°F), the deleterious effects of added aluminum upon oxidation resistance were readily apparent, but these materials possess satisfactory oxidation resistance to at least 2500°F. The room-temperature strength of $ZrBe_{13}$ containing added aluminum is greatly improved, but the high-temperature strength is much lower than that of normal $ZrBe_{13}$. The effect of 2% NiAl addition to $ZrBe_{13}$ was similar to that of the aluminum addition. Thermogravimetric oxidation-rate studies compare specimens of $ZrBe_{13}$, $Zr_2Be_{17}$, $ZrBe_{13}$ containing substantial amounts of $Zr_2Be_{17}$, and $ZrBe_{13}$ containing additions of iron and aluminum. Room-temperature, modulus-of-rupture data obtained on specimens which had been subjected to various thermal cycling treatments prior to testing showed that the apparent reduced strength at intermediate temperatures is merely a surface phenomenon, and that no mechanical damage to the interior of the specimen results from such thermal treatment. (auth)

**11083** (DMIC-Memo-161) ELECTRON MICROSCOPIC FRACTOGRAPHY. W. R. Warke and A. R. Elsea (Battelle Memorial Inst. Defense Metals Information Center, Columbus, Ohio). Dec. 21, 1962. 31p.

Electron microscopic fractography comprises the examination of replicas of fracture surfaces under the electron microscope and is a valuable tool for studying the fracture micromechanism and for analyzing service failures. The techniques of fractography are described, and the direct carbon and plastic-carbon methods of replication are compared. The characteristic appearances of various types of fractures under the electron microscope are described for overload fractures, fatigue fractures, and intergranular fractures. Possible areas for future research are discussed briefly. (D.L.C.)

**11084** (EURAEC-388) SINTERED URANIUM OXIDE — SINTERING TECHNIQUES — BEHAVIOR UNDER IRRADIATION. Quarterly Report No. 7, April 1 to June 30, 1962. (France. Commissariat a l'Energie Atomique, Paris). Work Performed under United States–Euratom Joint Research and Development Program. Contract 031-60-10RDF. 62p.

Production of $UO_2$ with specific surface of 12 to 18 $m^2/g$ by reduction of $UO_3$ is reported. Densities of 10.4 were achieved by $H_2$ sintering. Experiments are described in oxidation of $UO_2$ to $U_4O_9$. In other work, a leak-tight seal between Zircaloy-2 and stainless steel was effected, and a suitable Mo resistor was developed in dismantling tests and $UO_2$ capsule mock-up heating tests. Design of an out-of-pile circuit for trapping and counting fission gases is reported. (J.R.D.)

**11085** (GA-3064) BORON CARBIDE-GRAPHITE NUCLEAR CONTROL-ROD MATERIAL: PREPARATION, THERMAL STABILITY, AND IRRADIATION EVALUATION. Walter V. Goeddel, Harold K. Lonsdale, and Robert A. Meyer (General Atomic Div. General Dynamics Corp., San Diego, Calif.). Apr. 24, 1962. Contract AT(04-3)-314. 36p.

Boron carbide-graphite nuclear control-rod materials containing up to 45 wt % B were prepared by hot-pressing techniques. The densities of these compacts decreased with increasing B content. Compact strengths, however, were noticeably increased with B content of 20 wt %, suggesting that the B acts as a sintering aid. Thermal stability was evaluated by annealing compacts under a variety of temperature and atmospheric conditions. The upper limit of the loss of B was 5% to 10% in 200 hr at 2000°C — considerably less than would be predicted from the Langmuir evaporation equation. Diffusion of B atoms through the pores of the graphite, rather than evaporation from the surface, was found to be the rate-controlling step in the loss of B. Compacts containing 20, 30, and 40 wt % B were irradiated at 350 and 700°C to 1.0 and $2.4 \times 10^{21}$ nvt(fast). Physical integrity of the compacts was good after irradiation. Slight increases in tensile strength were noted in several instances. (auth)

**11086** (GEAP-3771-4) HIGH PERFORMANCE $UO_2$ PROGRAM. Quarterly Progress Report No. 4, January–March 1962. B. Weidenbaum (General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.). Apr. 1, 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(04-3)-189. 45p. (EURAEC-437)

Activities are reported in a program to measure the fission gas pressure in $UO_2$-filled fuel rods as a function of temperature and fuel configurations. The pressure buildup in the rods composed of low-enrichment $UO_2$ remained fairly constant, while rods containing higher enrichment $UO_2$ steadily increased throughout the irradiation, indicating a substantial fission gas release. In modification work on the existing pressurized water loop in the GE Test Reactor, the major changes were completed and testing is underway. Progress is reported in the $UO_2$ fuel performance tests to establish relations between the amount of fuel rod central melting and burn-up that can be obtained before fuel-cladding results in rod failure. Fabrication of 4 pellet-filled fuel assemblies and 1 Pb-filled dummy assembly for irradiation testing was completed during the quarter. Preliminary results of analyses of metallographic specimens irradiated at average heat fluxes of 600,000 and 800,000 BTU/hr-$ft^2$ indicate that control melting of ½-in. pellets occurred at a heat flux of

775,000 BTU/hr-ft$^2$. Irradiation of a third capsule with a hollow zirconia spacer in the center of the fuel column is reported; however, the capsule was not examined. (J.R.D.)

**11087** (GEMP-19A) HIGH TEMPERATURE MATERIALS PROGRAM PROGRESS REPORT NO. 19, PART A. (General Electric Co. Flight Propulsion Lab. Dept., Cincinnati). Jan. 25, 1963. Contract AT(40-1)-2847. 49p.

Stress-rupture results obtained with molybdenum at 2200°C in hydrogen and argon were essentially identical indicating little or no atmosphere effect. Previous data which indicated longer rupture life (and increased creep resistance) in the argon tests were discounted because of tungsten contamination of the sample material during testing as revealed by chemical analysis. Identical results at 2200°C in both hydrogen and argon were obtained on two of the three different heats of molybdenum employed in the stress-rupture tests. The third heat exhibited much longer rupture life, particularly at a stress level of 1000 psi. The reason for this difference was not identified but is probably caused by some material variability. The stress-rupture properties of tantalum at 2600°C were evaluated in two grades of argon and two grades of hydrogen. The stress-rupture life in argon was found to decrease as the dewpoint was decreased. Tungsten contamination was found on the surface of tantalum samples tested in the "wet" argon due, in all probability, to the transport of tungsten from the furnace heating element by the tungsten-water vapor cycle. There was no significant difference noted in the tantalum stress-rupture life test data obtained for tests conducted in commercial (2000 ppm impurities) and high purity grade hydrogen (5 ppm impurities). The preliminary experimental program on the refractory metals was initiated with the irradiation of several tungsten and molybdenum flat test specimens. Support equipment and furnaces for testing at high temperature in hydrogen or inert atmosphere or in vacuum are being assembled. Tensile data generated on Hastelloy X, and Rene' 41 is reported. The effects of irradiation on the stress rupture properties of overaged and underaged specimens of Rene' 41 are presented. Preliminary studies on the creep-rupture properties of Hastelloy X are illustrated in the form of specimen elongations as a function of testing time for various temperatures and stresses. Studies on the number of atom displacements in iron due to neutrons of various energies are discussed. The angular distribution of neutron scattering in iron and also the effect of the angle of neutron incidence on the medium are presented. The influence of material geometry on the number of atom displacements per unit flux is demonstrated by comparing the displacements in an iron column with those in an iron slab for various base widths and thicknesses. (auth)

**11088** (HW-73057) ON THE PACKING OF SPHERES FOR MAXIMUM DENSITY. R. L. Richardson (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). July 25, 1961. Contract AT(45-1)-1350. 12p.

Equations are given for calculating the method of packing spheres for maximum density. The calculations are based on packing the interstices of a rhombohedron formed with sphere centers at its vertices. Tables are included for calculations of special cases. (M.C.G.)

**11089** (HW-SA-2559) EFFECT OF GAS PRESSURE ABOUT ATMOSPHERIC ON RATE OF ETCHING AND SURFACE ROUGHNESS OF CATHODICALLY ETCHED METAL SURFACES. Thomas B. Correy (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). [May 13, 1962]. Contract AT(45-1)-1350. 35p.

It was found that a finite pressure of argon gas will produce minimal surface roughness when cathodically etching aluminum, copper, uranium, and Zircaloy-2 in an argon atmosphere at pressures from atmospheric to 29.8 inches (755 mm) of mercury below atmospheric. A very thin film followed by a thicker one can be selectively etched from some metals. Etching spots on the same metals disclosed that for a constant current they did not all reach the same or a limiting diameter of spot in the same time. A superimposed radiofrequency current is used to maintain the discharge. Cathodically etching in the transfer region between streamer discharge and gaseous discharge and in the gaseous discharge region were totally unsatisfactory. Indications are that helium can be used, but the etching rate is much lower for the same current and requires higher open-circuit potential for some metals. (auth)

**11090** (IS-460) PROGRESS IN SINTERING. D. R. Wilder (Ames Lab., Ames, Iowa). [Apr. 16, 1962]. Contract [W-7405-eng-82]. 30p.

Sintering is broadly defined as all aspects of the adhesion, densification, shrinkage, and consolidation which accompanies the reduction in surface energy of a powder compact which occurs upon application of heat and/or pressure. The process of sintering is then further divided into the initiation, material transport, and grain growth-recrystallization stages. A general review is made of each of these stages, noting typical work which has contributed to progress in each area involved. (auth)

**11091** (MITS-49) THE ADAPTATION OF NEW RESEARCH TECHNIQUES TO MINERAL ENGINEERING PROBLEMS. A Semi-Annual Progress Report for the Six-Month Period Ending October 31, 1962. (Massachusetts Inst. of Tech., Cambridge. Dept. of Metallurgy). Contract AT(30-1)-956. 43p. (NYO-10327)

Results of research on mixed adsorption from the gaseous phase on ferric oxide are reported. Results of adsorption measurements at hematite–water–diisobutyl ketone interfaces are also reported along with results on adsorption of inorganic ions on ferric oxide and hysteresis of contact angles in liquid-liquid-solid systems. The data on the liquid-liquid-solid systems were obtained using benzene-water-quartz in the presence of dodecylammonium chloride (DAC) in one experimental series, DAC-water-n-decane-rutile in a second series, and water-diisobutyl ketone-hematite in a third series. Other work is reported on the thickening mechanism investigated by study of kaolinite adsorption of polyacrylamide. (J.R.D.)

**11092** (NAA-SR-Memo-615) ELECTROMAGNETIC LEVITATION OF URANIUM — THE FREE SUSPENSION OF SOLID AND MOLTEN URANIUM IN SPACE. P. Gilbert (North American Aviation, Downey, Calif.). Mar. 2, 1953. Contract [AT(11-1)-Gen-18]. 11p.

Electromagnetic levitation of several heavy metals in the liquid state, including uranium, was carried out by means of a high-frequency current in a suitable coil. A 7-g sample of uranium was levitated in a ½-in. test tube. The uranium was maintained in complete levitation in the form of a conical top with dangling tail during the short time interval that elapsed while the uranium heated from its melting point to about 1600°C. A 4-g piece of U–0.3% Mo was levitated in the form of a prolate spheroid. The levitation of molten silver was also carried out. The theory of levitation is discussed, and coil design is described. (M.C.G.)

**11093** (NMI-2112) FUNDAMENTAL AND APPLIED RESEARCH AND DEVELOPMENT IN METALLURGY. Progress Report to United States Atomic Energy Com-

mission for the Month of November 1962. (Nuclear Metals, Inc., Concord, Mass.). Jan. 18, 1963. Contract AT(30-1)-2784. 12p.

Work was continued toward producing an ultra-high purity crystal by direct zone refining of distilled beryllium. Spark machining of previously produced crystals to obtain test specimens was also continued. W–Ru, Ta–Ru, and Nb–Re alloys were fabricated by extrusion techniques. Hot-hardness studies were made on refractory metals and alloys. Work was continued on a program to develop uranium-base alloys strengthened by SLIS techniques. (M.C.G.)

**11094** (NMI-2113) FUNDAMENTAL AND APPLIED RESEARCH AND DEVELOPMENT IN METALLURGY. Progress Report to United States Atomic Energy Commission, December 1962. (Nuclear Metals, Inc., Concord, Mass.). Feb. 6, 1963. Contract AT(30-1)-2784. 15p.

Six zone-refining passes were made on a bar of directly consolidated distilled beryllium. Three consolidation passes were completed on two sets of cold compacts of flake beryllium for impurity addition studies. Resistance ratio measurements and chemical analyses were obtained on specimens from a completed crystal which contained iron as an impurity addition. The fabricability of extruded alloys of refractory materials is being studied. Rolling and swaging of Ta, Ta–Ru, and Nb–Re were investigated. Hardness values are presented for Mo, Mo–Os, Mo–Re, Mo–Hf, Mo–Re–Hf, Ta, Ta–W, Ta–Re, and Ta–Re–W. Efforts were continued to achieve satisfactory pouring and shooting of molten uranium. Tungsten tubing was extruded for testing. (M.C.G.)

**11095** (NMI-7254) POWER REACTOR PROGRAM. Progress Report to Savannah River Operations Office, United States Atomic Energy Commission for the Period August 1, 1962–August 31, 1962. S. Isserow, R. W. Anderson, and W. L. Larson (Nuclear Metals, Inc., Concord, Mass.). Oct. 8, 1962. Contract [AT(30-1)-1565]. 18p.

Hardness testing of U–350 ppm Fe–900 ppm Al at elevated temperatures has shown that a hardness transition temperature above 400°C cannot be developed in beta treated specimens by subsequent alpha-phase heat treatments. Marked improvement of the extrusion behavior of the Al–Fe–U composition is obtained by the addition of 400 ppm Si. This addition permits achievement of a smooth surface in the extruded alloy without the usual alpha-phase working of the billet. The smoothness of an extruded surface is not predicted by metallographic observations of the grain size of the billet. The susceptibility to cracking during oil quenching from the beta phase increased as the Si content increased to 1100 ppm. Limited data on the hot hardness and microstructure of Al-Si-U alloys showed that this system has properties believed desirable in a fuel alloy and warrants further development. A survey of the elevated temperature properties was completed for dilute cast alloys containing to 1.5 wt % Mo. It was found that maximum solid solution hardening at 600°C is obtained with 1000 ppm Mo. The solid solution hardening by Mo at 600°C is greater than the hardening by Fe, Al and Si, singly or in combination. It was also found that metastable increases of hardnesses and hardness transition temperature can be developed in alloys containing 0.15 and 0.4 wt % Mo. Aging at 540°C reduces the metastable properties to the solid solution hardening level. Relatively stable increases in hardness and hardness transition temperature can be obtained with additions of at least 1 wt % Mo. In the effort to develop procedures to braze end closures ranging from 0.25 to 1.0 in. long in coextruded tube sections, further data were obtained on the conditions of heat application and extraction necessary to obtain high quality closures. (auth)

**11096** (NMI-7256) POWER REACTOR PROGRAM. Progress Report to Savannah River Operations Office, United States Atomic Energy Commission for the Period October 1, 1962 through October 31, 1962. S. Isserow, R. W. Anderson, W. J. Richmond, D. M. Davies, and W. L. Larson (Nuclear Metals, Inc., West Concord, Mass.). Nov. 30, 1962. Contract AT(30-1)-1565. 31p.

A short thin-walled enriched U–1.5 wt % Mo tube originally fabricated for testing at Vallecitos was processed and shipped for testing in the HWCTR with a previously processed companion tube. To further the development of new fuel compositions, short tubular specimens of unalloyed U and the U–350 ppm Fe–900 ppm Al alloy are being fabricated for irradiation in the HWCTR. As part of the effort to develop a fuel material with improved irradiation behavior, metallurgical studies were continued on U–Fe–Al alloys modified with various amounts of either Si or Cr. Hardness tests showed that only 200 ppm Si is necessary to develop the maximum hardness in the beta quenched alloy; no further benefit is obtained with additions of Si to 1100 ppm. The hardening effect of Si is markedly reduced by overaging at 600°C. In the aged material, Si still has a hardening effect, which increases with Si content to 1100 ppm and is at least partly a dispersion hardening effect. Additions of Cr increase the hot hardness of the beta quenched U–Fe–Al to the level obtained with Si additions. In contrast to the Si additions, the Cr additions do not contribute to the hardness of the U–Fe–Al after overaging at 600°C. In the effort to develop techniques for brazing end closures on coextruded fuel tubes, improved control of induction heating apparently can be achieved with a modified coil design and a 10,000 cycle power supply. (auth)

**11097** (NMI-7257) POWER REACTOR PROGRAM. Progress Report to Savannah River Operations Office, United States Atomic Energy Commission for the Period November 1, 1962 through November 30, 1962. S. Isserow, R. W. Anderson, D. M. Davies, W. L. Larson, and A. B. Bremer (Nuclear Metals, Inc., West Concord, Mass.). Dec. 27, 1962. Contract AT(30-1)-1565. 19p.

For the preparation of short tubular specimens for irradiation in the HWCTR, two unalloyed uranium tubes were extruded and U–350 ppm Fe–900 ppm Al core stock is being processed. Corrosion testing of Zircaloy-2 has shown that the film formed during heat treatment in salt is followed by excessive weight gains in 360°C water. In light of these results, it will be necessary either to protect the specimen from the salt during heat treatment or to remove the film after heat treatment. In the effort to develop an improved fuel composition, uranium containing 350 ppm iron, 450 ppm aluminum, 350 ppm silicon, and 150 ppm chromium was evaluated by metallographic and hot hardness tests. The hot hardness of this alloy in the beta-quenched condition is comparable to that of U–Fe–Al modified with either silicon or chromium, with the exception that the hardness transition temperature for the U–Fe–Al–Si–Cr is about 50°C above that of the other alloys. The hardness of NMI's wrought U–Fe–Al–Si–Cr resembles that of a cast sample from another source. For brazing end closures on short tubes for HWCTR, a straight heating coil used with a 10,000 cycle induction heating power supply gave satisfactory brazes. Fabrication processes are being adapted to accommodate changes in core composition and dimensions of the redesigned

driver tubes. X-ray fluorescence was selected as the method for the determinatfon of uranium in the core alloy. Experiments were initiated to aid the selection of the co-extrusion temperature and end shape designs. (auth)

**11098** (NP-12433) ALKALI METALS BOILING AND CONDENSING INVESTIGATIONS. Quarterly Report No. 1, July 1, 1962 thru September 30, 1962. (General Electric Co. Spacecraft Dept., Cincinnati). Contract NAS 3-2528. 66p.

Activities in a program to obtain two-phase heat transfer data for Na and K under conditions of boiling and condensing are reported. Data obtained during the report period concerning boiling heat transfer are tabulated for the 300-kw loop, and information obtained in an investigation to improve heat transfer measurements is included. Data are also included concerning pressure drop in the 300-kw loop. (J.R.D.)

**11099** (NP-12475) INVESTIGATION OF STRESS-CORROSION CRACKING OF HIGH-STRENGTH ALLOYS. Report No. L0414-01-20. Progress Report No. 20, November 1–November 30, 1962. P. L. Jordan (Aerojet-General Corp., Azusa, Calif.). Jan. 24, 1963. Contract DA-04-495-ORD-3069. 8p.

Chemical compositions and mechanical properties are tabulated for 6Al-4V titanium, 20%-nickel maraging steel, and high-titanium 18%-nickel maraging steel. The status of the stress-corrosion cracking tests and development of protective coatings is outlined. (D.L.C.)

**11100** (NP-12493) DEFENSE METALS INFORMATION CENTER SELECTED ACCESSIONS. (Battelle Memorial Inst. Defense Metals Information Center, Columbus, Ohio). Dec. 1962. 55p.

A list of 86 selected documents and journal articles is presented in an abstracted form. The list is arranged in sections dealing with high-strength alloys, light metals, nonmetallics, refractory metals, and miscellaneous (coatings, applications, and composites). Author and subject indexes are included. (D.L.C.)

**11101** (NUMEC-P-49) FEASIBILITY OF PRODUCING SPHERICAL BERYLLIUM PARTICLES. Final Report. L. A. Hughes and H. J. Garber (Nuclear Materials and Equipment Corp., Apollo, Penna.). [1960]. Contract AT(30-1)-2913. 18p.

Limited studies were carried out on two possible techniques of producing spherical Be metal particles of size 5 to 13 mils diameter: (1) a salt bath technique whereby molten Be droplets are dropped into a molten salt, and (2) a shot tower technique in which molten Be is dropped against a refractory oxide disc rotating at high speed. The pertinent properties of Be and U metal for spheroidization are discussed. The salt bath technique was studied using the Woods metal–water system; the maximum perfect sphere yield was limited to ~ 50%. However, the studies of Be spheroidization in KF–KI eutectic and by dropping against a rotating disc failed owing to experimental difficulties. (D.L.C.)

**11102** (NYO-9735) INVESTIGATIONS OF RADIOACTIVE FUEL-BEARING GLASSES. Period Covered: May 1, 1960–March 31, 1961. P. A. Lockwood (Owens-Corning Fiberglas Corp. Technical Center, Granville, Ohio). July 31, 1961. Contract AT(30-1)-2489. 49p.

A series of glass compositions containing uranium oxide was investigated to determine fiberizability and physical properties of resultant fibers. The basic properties to be determined were the maximum $U_3O_8$ content in a fiberizable glass and the maximum service temperature of the fibers. Glasses containing 60 wt % $U_3O_8$ were fiberizable; the fibers had strengths of 100,000 psi at 1600°F. Fiber-forming equipment was installed at Mound Laboratory to produce glass fibers containing $PuO_2$. Fibers were successfully formed in the first trials. For additional work a series of base glasses were provided affording a wider range of both $PuO_2$ solubility and physical properties. (auth)

**11103** (TID-16243) LOW TEMPERATURE GALVANOMAGNETIC PROPERTIES OF GRAPHITES. G. L. Montet (Argonne National Lab., Ill.). May 1962. Contract [W-31-109-eng-38]. 43p. (UAC-6477)

The electrical resistances and Hall coefficients of polycrystalline graphite, neutron irradiated graphite, chemically doped graphite, and neutron irradiated chemically doped graphite were measured over a range of magnetic fields at liquid nitrogen and liquid helium temperatures. The empirical equivalence of acceptor concentrations in irradiated graphite and in chemically doped graphite obtained by matching Hall coefficients was found to be a function of the temperature of measurement. This observation may be explained in terms of temperature-dependent trapping efficiencies of the electron traps introduced chemically or by neutron irradiation. This explanation affords some understanding of the electrical properties of the complicated neutron irradiated chemically doped graphite. The temperature variation of the resistances and Hall coefficients of the graphites studied may be reasonably well understood on the basis of the phenomenological theory of transport properties. Anomalous variations with magnetic field of resistances and Hall coefficients were observed at low temperature in some of the graphites studied; no satisfactory explanation has been found for these effects, although a recently introduced theory provides a plausible explanation for the observed magnetoresistance of polycrystalline graphite at liquid helium temperature. (auth)

**11104** (TID-16252) NOTES ON THE UNIFORMITY OF COMMERCIAL FOILS. L. C. Becker, G. K. Tandon, F. C. Jobes, J. A. McIntyre, and T. L. Watts (Yale Univ., New Haven). [July 5, 1962]. Contract [AT(30-1)-2726]. 20p.

The uniformity of the thickness of thin foils was measured for aluminum, mylar, nickel, and silver. The mylar and nickel foils are uniform to better than 1%, the aluminum to 4%, and the silver to 6%. The non-uniformities in the aluminum are shown to occur over small regions of the foil surface (< 3mm). (auth)

**11105** (TID-17734) TUNGSTEN–RHENIUM THERMOCOUPLES FOR DIFFICULT TEMPERATURE MEASUREMENTS OF ZIRCALOY-2 WELDMENTS. W. A. Owczarski (Knolls Atomic Power Lab., Schenectady, N. Y.). [Nov. 12, 1962]. Contract [W-31-109-eng-52]. 10p.

Development of a method of attaching W–Re thermocouples to Zircaloy-2 for use in recording weldment data is reported. Instrumentation was also developed which provides reasonably accurate measurements of the thermal cycles in the heat-affected zones of the weldment. It is noted that the instrumentation may be used in more complete analyses of the heat-affected zones of weldments. (J.R.D.)

**11106** (UNC-5040) FUEL CYCLE DEVELOPMENT PROGRAM. Quarterly Progress Report, July 1 to September 30, 1962. (United Nuclear Corp. Development Div., White Plains, N. Y.). Oct. 31, 1962. Contract AT(30-1)-2374. 15p.

Under Task I, irradiation testing of Capsule UNC-3-1

was resumed in the ETR and is scheduled for completion in January 1963. Under Task II, thermal expansion determinations of uranium carbide were delayed after the apparatus was found defective. The equipment was repaired and tests are being resumed. Thermal conductivity tests are awaiting the release by the AEC of a subcontract to another laboratory. The apparatus for determining hot hardness of uranium carbide is being checked out. Irradiation test specimens of uranium carbide are still being irradiated in MTR. Capsules UNC-1-2 and UNC-1-3 will be removed by the end of October after receiving 15,000 Mwd/ton U. Capsule UNC-1-1 will remain in MTR until a burnup of 30,000 Mwd±ton is achieved. This is currently estimated to occur in July 1963. Examination of cast uranium carbide, exposed for a year under varied conditions, indicated satisfactory resistance of 4.5 and 4.7 wt.% carbon material to corrosion by laboratory air. Laboratory air caused transverse cracking of 5.3 wt.% carbon specimens after five months. Uranium carbide specimens stored in vacuo showed some surface attack and slight pitting but no cracking. Carbon content of these specimens did not appear to have any effect on corrosion behavior. (auth)

**11107** (EURAEC-5(Rev.)) THE IMPROVED SINTERING OF URANIUM OXIDE WITH A VIEW TO INCREASING ITS THERMAL CONDUCTIVITY. Quarterly Report No. 1. (Compagnie Générale de Télégraphie Sans Fil, Paris). June 29, 1960. Work Performed under United States–Euratom Joint Research and Development Program. Contract 004-60-3-RDF. 22p. A translation.

The purity and sintering of $UO_2$ are discussed, and the effects of adjuvant oxides on the sintering are studied. Some of the physical constants of $UO_2$ are given, and it is shown that the effects of additives on the neutron absorption are negligible. Thermal conductivity measurements are reported for $UO_2$ sintered without adjuvant. (D.L.C.)

**11108** (EURAEC-307) THE USE OF PLUTONIUM AS FUEL IN NUCLEAR REACTORS. Quarterly Report No. 7, January–March 1962. (Société Belge pour l'Industrie Nucléaire, Brussels; Brussels. Centre d'Étude de l'Energie Nucléaire; and Brussels. Université). Apr. 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 27-60-7RDB. 134p. A translation of BN-6204-08.

Includes Annex V: PRELIMINARY RESEARCH TO THE PRODUCTION OF ZIRCONIUM ALLOY POWDERS BY MEANS OF IGNEOUS ELECTROLYSIS.

Studies were carried out on the fabrication and characterization of $UO_2$ and $PuO_2$, PuC and UC, and dispersion fuels in metallic matrixes. Procedures were worked out for the titration of solutions for U and Pu, for the surface determination of $PuO_2$, and for Pu recycling and purification. (D.L.C.)

**11109** (EURAEC-338) THEORETICAL AND TECHNOLOGICAL STUDY OF NUCLEAR FUELS BASED ON COMPOSITE REFRACTORY PELLETS. Quarterly Report No. 1, December 15, 1961 to March 31, 1962. (Compagnie pour l'Étude et la Réalisation de Combustibles A Atomiques, Bonneuil-sur-Marne, France). Work Performed under United States–Euratom Joint Research and Development Program. Contract 077-61-12RDF. 121p. A translation.

Calculations on lattices comprising $ThO_2$ cores with $UO_2$ crowns resulted in development of reliable recurrence formulas for thermal utilization coefficients, anti-strike factors, and rapid fission factor. In other work, fabrication methods were investigated in which $UO_2$ was cast in an annular space between a $ThO_2$ core and a circular mold. Work is also reported on preparation of fuel specimens by pressing the $ThO_2$ core with $UO_2$ rings. Cores and rings of several densities were prepared and sintered to determine the proper test conditions for use. (J.R.D.)

**11110** (EURAEC-387) STUDY OF THE FORMING AND IRRADIATION OF URANIUM CARBIDE. Quarterly Report No. 6, April 1, to June 30, 1962. B. Mansard and P. Rousset (France. Commissariat a l'Energie Atomique, Paris). July 2, 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 012-60-5-RDF. 50p. A translation.

Research and development during the quarter was devoted mainly to optimum conditions for UC extrusion. Improved extrusion products were obtained after drawing frame profile modifications and changes in the extrusion pots. The graphite grain-size was reduced below $^{35}/_{\mu}$ U in tests aimed at reducing the U–C reaction density drop. Results indicate that fine graphite can be used for carbon contents of about 4.8%. Micrographic observations of a UC rod irradiated to 700 Mwd/t at 600°C showed grain enlargement which was thought to be the result of both factors. Density changes in the graphite were associated with lattice parameter changes. Plans are being made for graphite irradiations of 6000 Mwd/t at 1000°C. A study of ZrC for use as refractory casings in the high-temperature irradiation of UC was initiated. The high-temperature expansion coefficient of ZrC was determined as $8.24 \times 10^{-6}$/°C at 20 to 1300°C. In other work, development of fission gas extraction tests for high temperature experiments is in progress. (J.R.D.)

**11111** (EURAEC-407) PASTILLES COMPOSITES. Quarterly Report No. 2 and Annexe, April 1–June 30, 1962—March 15–June 15, 1962. (Compagnie pour l'Étude et la Réalisation de Combustibles Atomiques, Bonneuil-sur-Marne, France and Compagnie Industrielle des Combustibles Atomiques Frittés, Corbeville, par Orsay (Seine-et-Oise), France). Work Performed under United States–Euratom Joint Research and Development Program. Contract 077-61-12RDF. 95p. A translation.

Efforts during the quarter were devoted partially to a neutronic analysis to determine the coefficient of infinite multiplication in an environment charged with composite rods. Other work during the quarter was on casting, molding, and extrusion of fuel elements constructed with a $ThO_2$ core and a ring of $UO_2$. The fabrication method to be adopted will be either pressing or extrusion. (J.R.D.)

**11112** (EURAEC-409) COATING OF URANIFEROUS CERAMIC PARTICLES WITH NIOBIUM METAL. Quarterly Report No. 4, April to June 30, 1962. (Brussels. Societe d'Etudes, de Recherches et d'Applications pour l'Industrie). July 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 066-61-7RDB. 34p. A translation.

During the period, 18 complete coating processes were carried out. An attempt was made to establish the influence of the temperature on the coating properties. Several factors are listed which had not been foreseen and proved to have a strong influence on the results. The best coatings obtained were those carried out at temperatures ranging between 850 and 900°C. (W.D.M.)

**11113** (EURAEC-430) BASIC STUDY ON SOME OF THE FORMS OF EMBRITTLEMENT OCCURRING IN WELDED JOINTS MADE ON HIGH TENSILE STEELS. Quarterly Report No. 2, April 1 to June 30, 1962. (Société des Forges et Ateliers du Creusot, Paris). Work Performed under United States–Euratom Joint Research and Development Program. Contract 073-61-12-RDF. 23p. A translation.

Preliminary work such as bibliographic studies and test development is in progress. Two series of steel castings were completed and a third is planned to establish the effects of various refining elements, the standard constituents, and impurities. Data on grain size increase in terms of the austenization temperature are included for the first series of castings. Initiation of a study on the allotropic transformations in these castings is reported. (J.R.D.)

**11114** (EURAEC-477) STUDY OF THE SHAPING AND IRRADIATION OF URANIUM MONOCARBIDE. Quarterly Report No. 7, July 1–September 30, 1962. (France. Commissariat a l'Energie Atomique, Paris). Oct. 15, 1962. Work Performed under United States–Euratom Joint Research and Development Program. 10p. A Translation.

Development of equipment for use in subjecting UC to simulated reactor thermal conditions is reported. The equipment is scheduled for 1900 hrs of operation at 500 to 600°C. A study of a specially enriched UC fuel element was continued. This element is constructed with a double can filled immediately with NaK and provided with safety devices designed to detect and draw attention to slag burst. Fabrication of ZrC rods sintered to densities of 90% for irradiation testing is also reported. Further irradiations of the enriched UC are planned. (J.R.D.)

**11115** (EURAEC-482) QUARTERLY REPORT NO. 1 [ON CORROSION OF STAINLESS STEELS], JULY 1–SEPTEMBER 30, 1962. G. Chaudron [France. Centre National de la Recherche Scientifique, Paris]. Work Performed under United States–Euratom Joint Research and Development Program. Contract 085-62-7RDF. 8p. A translation.

Three 18/8 stainless steels were prepared from pure metals and their metalloid impurities were determined. The pure steels were found to undergo a spontaneous martensitic transformation at 104 to 130°C and are martensitic at ambient temperatures, while commercial steel is austenitic. The recrystallization temperatures after work-hardening were determined for the three steels. The corrosion rates of commercial 304 steel and the three pure steels in 6 N HCl were measured. Two of the pure steels were found to have high corrosion resistance. (D.L.C.)

**11116** (EURAEC-487) STUDY ON THE COATING OF URANIFEROUS CERAMIC PARTICLES WITH NIOBIUM METAL. Final Report No. 1. (Brussels. Societe d'Etudes, de Recherches et d'Applications pour l'Industrie). July 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 066-61-7RDB. 76p. A translation of BN-6208-15.

The process of coating ceramic particles with niobium in a fluid bed is described. Factors influencing the process were investigated in about 30 coating operations. The process consists of injecting a hydrogen and $NbCl_5$ mixture into a reaction vessel where the gas keeps in suspension the ceramic particles to be coated. Thermodynamic aspects of the reduction of $NbCl_5$ by hydrogen and the fluidization of spherical $UO_2$ particles are discussed. (M.C.G.)

**11117** (EURAEC-491) BASIC STUDY OF THE IN-PILE BEHAVIOR OF PLUTONIFEROUS MATERIALS. Quarterly Report No. 4. (Société Belge pour l'Industrie Nucléaire, Brussels). Oct. 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 078-61-12RDB. 42p. A translation.

The thermal conductivity of $UO_2$ was found to decrease at 1200 to 1400°C and then increase to its melting point. In other research, the gamma-densimetric examination was perfected and completed. Details of other pre-irradiation tests are given along with conditions and results of fuel irradiations. In post-irradiation work, the construction, adjustment, and mockup-cell testing of instruments were continued. (J.R.D.)

**11118** (EURAEC-496) THE SHAPING AND IRRADIATION OF URANIUM MONOCARBIDE. Final Report, December 15, 1960 to December 15, 1961. (France. Commissariat a l'Energie Atomique, Paris). Sept. 30, 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 012-60-5 RDF. 32p. A translation of CEA-3748.

Experiments are described on the irradiation behavior of UC. It was found that the diffusion coefficient of UC is appreciably lower than that of $UO_2$. It was also found that hydrolysis of UC yields methane. The preparation of UC and U-UC cermets by sintering-extrusion is also reported. Conditions were found for the production of high-density homogenized U-C mixtures in the form of rods. (J.R.D.)

**11119** (JPRS-17322) SEMINAR—PRODUCTION METHODS, PHYSICAL PROPERTIES, AND ELECTRONIC STRUCTURE OF THE REFRACTORY METALS, THEIR COMPOUNDS AND ALLOYS. SUMMARIES OF REPORTS. Translation of "Seminar—Metody Polucheniya, Fizicheskie Svoistva i Elektronnoe Stroenie Tugoplavkikh Metallov, Ikh Soedinenii i Splavov—Tezisy Dokladov" p.1-64, 1961. (A publication of the Publishing House of the Academy of Sciences, Ukrainian, SSR, Kiev). 56p.

The summaries concern the physical, chemical, and electric properties of metals, refractory materials, and ceramics. (J.R.D.)

**11120** ALUMINIUM ALLOYS AS CLADDING MATERIALS FOR NUCLEAR REACTORS—AN INVESTIGATION OF FABRICATION AND CORROSION PROPERTIES. K. Hannerz. R. Lindblad, A. W. Magnusson. ASEA (Allmanna Svenska Elektriska Aktiebolaget) Res., No. 7, 7-28 (1962).

The behavior of certain aluminum alloys for cladding purposes was evaluated by testing the corrosion properties of welded specimens in flowing water for 1150 to 5000 hr at temperatures of 160 and 210°C. The fabrication problems, especially welding techniques were closely studied. End closures for cladding tubes were satisfactorily welded. One of the tested alloys, containing Si as the major alloying element, exhibited superior corrosion properties compared with the other alloys tested. (Atomdokumentation, 14: No. 13, Nov. 1962)

**11121** THE METALLURGICAL LABORATORY AT RISÖ. Niels Hansen (Danish Atomic Energy Research Establishment, Risø, Denmark). Ingeniøren, 6: 92-100 (Oct. 1962). (In English)

Current work in reactor metallurgy includes development of a fuel element for Risø's reactor study project. The finned sintered aluminum product tube to be filled with uranium dioxide pellets is undergoing heat, corrosion, and neutron dose tests. A process for producing uranium dioxide pellets from powder is being developed as is a technique for filling and scaling fuel rods. Work on metallic uranium and uranium alloys is aimed at achieving better burn-up in fuel elements. Influence of impurities on grain size of uranium carbide and properties of dispersion strengthened alloys are also being investigated. Description of the laboratory and its facilities for various tests are included. (D.C.W.)

**11122** GROWTH OF BERYLLIA SINGLE CRYSTALS. Stanley B. Austerman (Atomics International, Canoga Park, Calif.). J. Am. Ceram. Soc., 46: 6-10(Jan. 21, 1963).

Single crystals of beryllia were grown by two methods.

The transpiration method of crystal growth, which depends on the reversible reaction $BeO + H_2O \rightleftharpoons Be(OH)_2$, yielded small perfect crystals suitable for limited study. Production of large crystals was hampered by severe polynucleation, which probably was caused by uncontrolled impurities. By the flux method crystals were precipitated from molten lithium molybdate saturated with dissolved BeO. Crystals up to 5 mm were grown. Growth of good-quality crystals in larger sizes was complicated by the formation of internal voids, possibly due to impurity interferences at growth steps, and by dense crystal nucleation. Characteristics and some problems of the two methods are discussed, and the crystals produced are described. (P.C.H.)

**11123** REACTOR MATERIALS. Volume 5, No. 3. R. W. Dayton, E. M. Simmons, and R. W. Endebrock (Battelle Memorial Inst., Columbus, Ohio). Aug. 1962. 80p. (GPO) $0.55 (domestic), $0.70 (foreign). (One of the Technical Progress Reviews prepared quarterly for the Division of Technical Information, USAEC).

The properties, behavior, and fabrication of materials applicable to nuclear reactor components and associated equipment are reviewed. The information is presented in sections on fuel and fertile materials, moderator materials, nuclear poisons, cladding and structural materials, and special fabrication techniques. (J.R.D.)

**11124** REACTOR MATERIALS. Volume 5, No. 4. R. W. Dayton, E. M. Simmons, and R. W. Endebrock (Battelle Memorial Inst., Columbus, Ohio). Nov. 1962. 93p. (GPO) $0.55 (domestic), $0.70 (foreign). (One of the Technical Progress Reviews prepared quarterly for the Division of Technical Information, USAEC).

Progress on studies of radiation effects in reactor ceramics, fuel and fertile materials, moderator materials, nuclear poisons, cladding and structural materials, and special fabrication techniques is reviewed. Separate abstracts were prepared for each topic. (M.C.G.)

**11125** RADIATION EFFECTS IN REACTOR CERAMICS. T. S. Elleman and T. G. Knorr. p.1-15 of "Reactor Materials. Volume 5, No. 4."

Mechanisms of radiation damage in ceramics are summarized, and a number of the property changes that occur in the radiation field of a reactor are discussed. Topics covered include: cause of damage, nature of defected region, radiation exposure, dimensional changes, alteration of mechanical properties, phase transformations, changes in thermal conductivity, chemical-reactivity changes, changes in diffusion rate, and annealing of defects. (M.C.G.)

**11126** FUEL AND FERTILE MATERIALS. p.16-42 of "Reactor Materials. Volume 5, No. 4."

Research progress is reported on uranium and its alloys, plutonium alloys, plutonium compounds, thorium, dispersion fuels, coated-particle fuel materials, refractory fuel and fertile materials, and basic studies of radiation effects on fuel materials. (M.C.G.)

**11127** MODERATOR MATERIALS. p.43-54 of "Reactor Materials. Volume 5, No. 4."

Research progress is reported on graphite, beryllium metal and alloys, beryllium oxides, beryllides, and solid hydrides. (M.C.G.)

**11128** NUCLEAR POISONS. p.55-6 of "Reactor Materials. Volume 5, No. 4."

Research progress is reported on metallic poison materials, and dispersion control, and shielding materials such as $HfB_2$, Hf-V, Hf-Ir, rare earths, $B_4C$-Ni, $B_4C$-SiC, and $Eu_2O_3$ dispersions. (M.C.G.)

**11129** CLADDING AND STRUCTURAL MATERIALS. p.57-78 of "Reactor Materials. Volume 5, No. 4."

Progress is reported on: corrosion studies of Zr, Al, stainless steel, Fe alloys, Ni alloys, and refractory metals (coated and uncoated); corrosion by liquid metals and fused salts; radiation effects on non-fuel material; selected mechanical properties of cladding and structural materials; selected metallurgical aspects of cladding and structural materials; diffusion studies; and ceramic technology. (M.C.G.)

**11130** SPECIAL FABRICATION TECHNIQUES. p.79-90 of "Reactor Materials. Volume 5, No. 4."

Progress is reported on techniques of melting, hot and cold working, cladding, welding and brazing, explosive forming, and nondestructive testing. (M.C.G.)

## Corrosion

*Refer also to abstract 10512.*

**11131** (AGC-0584-04-5) MERCURY CORROSION LOOP TESTING PROGRAM. (Aerojet-General Corp., Azusa, Calif.). Jan. 1963. Contract NAS 3-1925. 33p.

The fabrication, testing, and analysis work accomplished during the fifth quarter (October through December 1962) of the Mercury Corrosion Loop Testing Program are described. Intermittent operation of Loop No. 1 was continued. A testing program was started to determine the clearances required for the most efficient operation of each Haynes 25 pump. Tubing for Loop No. 2 was fabricated, and the loop was assembled. Design of the follow-on corrosion loops was initiated. Development of techniques for fabrication of loops constructed of Nb–1% Zr tubing clad with 316 stainless steel was started. (auth)

**11132** (KAPL-M-AA-4) THE EFFECTS OF ANNEALING ON THE CORROSION RATE OF PREOXIDIZED ZIRCALOY 2. C. L. Crenshaw and A. M. Andrako (Knolls Atomic Power Lab., Schenectady, N. Y.). Nov. 13, 1962. Contract W-31-109-eng-52. 19p.

Zircaloy-2 coupons, fabricated from three different ingots of reactor-grade Zircaloy, were given an acceptable proof test for three days in 680°F water. Subsequently, the coupons were annealed at various temperatures (752 to 1112°F) for various time periods (1, 2, or 5 hours). Then the corrosion coupons were tested in 550°F pH 10.5 lithiated water for 147 days. The corrosion resistance of Zircaloy with a proof test corrosion product film is strongly decreased by annealing, particularly at the higher temperatures and longer times. The strong deleterious effect of annealing temperature and annealing time on amount of corrosion increases with increasing corrosion time. However, the effect on rate of corrosion decreases with increasing corrosion time, largely because the rates themselves are decreasing strongly with increasing time. The annealing temperature was the only variable which affected the final corrosion rate (63 to 147 days). (auth)

**11133** (TID-16561) CORROSION IN ENERGY CONVERSION SYSTEMS (NUCLEAR). Cornelius Groot (Knolls Atomic Power Lab., Schenectady, N. Y.). June 21, 1962. Contract W-31-109-eng-52. 28p.

Energy Conversion Systems (Nuclear) have their corrosion problems. At the present time, corrosion of the fuel element cladding limits reactor power and efficiency. Reactor corrosion problems are mostly solved or mitigated by materials choice. The reactor environment (the primary water) is optimized for the main materials of construction, generally stainless steel, and the other mate-

rials are chosen to be compatible with that. Decontamination of a reactor leads to a whole host of complex corrosion problems. Materials satisfactory for normal operation may prevent the use of otherwise desirable decontamination systems. (auth)

**11134** (EURAEC-474) CORROSION STUDIES ON STEELS IN WATER AND VAPOR AT HIGH TEMPERATURE. Quarterly Report No. 1, June 16 to September 30, 1962. (Brussels. Societe d'Etudes, de Recherches et d'Applications pour l'Industrie). Oct. 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 089-62-7RDB. 60p. A translation.

Preparations for tests to examine the effects of the surface state on corrosion of steel in water and vapor at high temperatures are reported. (J.R.D.)

**11135** (EURAEC-483) STUDY OF SOME OXIDATION PROBLEMS OF METALS AND APPLICATION OF IMPEDANCE MEASURING METHODS TO THE STUDY OF THE RESISTANCE TO CORROSION DUE TO AN AQUEOUS MEDIUM. Quarterly Report No. 2, (Parts 1 and 2) July 1 to September 30, 1962. (Brussels. Universite). Work Performed under United States–Euratom Joint Research and Development Program. Contract 081-62-5 RDB. 41p. A translation.

Oxide formation on metals heated to high temperatures in oxidizing atmospheres was studied. Results are included on the Cu/O and Cd/O systems. Information obtained in studies of Cu–Ni alloy oxidation is also included. Impedance-measuring methods were developed to study corrosion in aqueous media, and results of tests made with Au and Pt electrodes in $NaClO_4$ and KCl are reported. (J.R.D.)

**11136** HOW CIR TEAM SOLVED CORROSION, DEPOSITION PROBLEMS. V. Surya Rao, V. V. Kothare, J. Shankar, K. S. Venkateswarlu (Atomic Energy Establishment, Trombay, India). Can. Nucl. Technol., 2: 27-30(1963).

Severe difficulties were experienced at the Canada-India Reactor (Trombay, India) soon after criticality was attained on 10 July 1960, mainly in maintenance of the required cooling-water flow rates through the annuli around the uranium fuel rods. Troubles included bacterial growth in the cooling water and corrosion of the aluminum cladding surface of the fuel rods. Addition of dichromate to inhibit bacteria made the corrosion worse. This article details the sixteen months' work which resulted in a final solution. (auth)

**11137** BIBLIOGRAPHY ON CORROSION INHIBITORS FOR HIGH PURITY WATER. A Report of NACE Technical Unit Committee T-3F on Corrosion by High Purity and Related Waters in Nuclear Power and Steam Generating Plants. Prepared by Task Force T-3F-2 on Inhibitors. Corrosion, 19: 26t-36t(Jan. 1963).

References (130) are given to U. S. and foreign journals and patents published from 1950 to 1960. The references are listed under various inhibitors. (P.C.H.)

**11138** THE MECHANISM OF ANODIC OXIDATION. G. Amsel (Ecole Normale Supérieure, Paris) and David Samuel. Phys. Chem. Solids: 23: 1707-18(Dec. 1962).

The ion transport mechanism in the growth of oxide films during anodic oxidation is studied. Tracer methods are used to determine the order of the atoms in the film. The position of the labelled atoms is determined by observing the form of excitation curves near sharp resonances of the reactions $O^{18}(p,\alpha)N^{15}$ and $Al^{27}(p,\gamma)Si^{28}$. Perfect conservation of the order is observed for oxygen, whereas metallic atoms show a slight mixing. A model is proposed in which the oxygen sublattice remains stationary and the metal atoms move by vacancy diffusion and by interstitial exchange capture. A mathematical analysis of the model is presented. (auth)

**11139** THE TEMPERATURE DEPENDENCE OF THE STRESS CORROSION OF Al–Zn–3% Mg. Wolfgang Gruhl (Vereinigten Leichtmetall-Werke G.m.b.H., Bonn). Z. Metallk., 53: 670-5(Oct. 1962). (In German)

The temperature dependence of the stress-corrosion of Al–Zn–3% Mg between 25 and 70°C under constant tensile strength was determined, confirming the relation $Z = K^* \cdot e^{cQ}$. The discussion of the results indicates that the temporal course of stress-corrosion is due to the traveling speed of single vacancies in the case of undeformed and double vacancies in the case of deformed materials. (auth)

## Fabrication

*Refer also to abstract 12013.*

**11140** (AMC-TR-7-775(VII)) COLUMBIUM ALLOY EXTRUSION PROGRAM. Phase V. Tubing Program Interim Report VII, October 15, 1962–January 15, 1963. James S. Clark (Du Pont de Nemours (E. I.) & Co. Metals Center, Baltimore). Contract AF33(600)-40700. 63p.

An additional B-66 ingot and an X-110 ingot, each 8 in. in dia., were melted and converted to 4 in. round billet stock by warm extrusion. This brought the total of 8 in. dia. ingots used in this phase of the contract to six, three of each alloy. The additional ingots were required to offset the low yield incurred in the initial tube blank extrusion campaign. The major effort in this three-month period was the development of the tube blank extrusion operation. A process was developed which produced tube blanks with much improved surfaces over the initial extrusions in the program. The improvement was attributed to the refinement of the glass lubrication practice used in conjunction with a cone die. Transverse checks persist on the inside surface, however. A total of 23 extrusions were attempted, all at 3000 to 3200°F. Die type, glass lubrication practice, and billet design were the major parameters investigated. Seventeen of the 23 billets were extruded but only 13 tube blanks were considered satisfactory for the tube reduction program. Considerable difficulty was encountered in conditioning. A major problem arose in conditioning the outside surface of the tube blanks. Repeated straightening attempts at ambient temperature resulted in fracture. A deep pickling operation combined with hand-grinding to remove surface defects was the most effective method of conditioning. The first tube reduction on the initial batch of four X-110 tube blanks was completed. The two B-66 tube blanks cracked radially in the first tube reducing pass. A possible source of the cracks is residual extrusion surface defects, present despite extensive conditioning prior to the tube reduction. (auth)

**11141** (CEND-153(Vol.I)) SYMPOSIUM ON POWDER PACKED URANIUM DIOXIDE FUEL ELEMENTS, NOVEMBER 30–DECEMBER 1, 1961. VOLUME I. (Combustion Engineering, Inc. Nuclear Div., Windsor, Conn.) Work Performed under United States–Euratom Joint Research and Development Program. Contract [AT(30-1)-2379]. 179p.

Eleven papers and three abstracts of papers presented at the Symposium on Powder Packed Uranium Dioxide Fuel Elements are given. Topics covered include: general powder-packed fuel elements, vibratory compaction of $UO_2$, and swaging of $UO_2$ fuel elements. Separate abstracts were prepared for each of the 11 papers. (M.C.G.)

**11142** (CEND-153(Vol.I)(p.3-10)) ECONOMICS OF POWDER PACKED FUEL ELEMENTS. B. E. Murtha and W. P. Chernock (Combustion Engineering Inc. Nuclear Div., Windsor, Conn.).

A number of $UO_2$ fuel concepts were investigated to determine which of these offered sufficient economic incentives for development. The framework of reference for this evaluation was the Advanced Pressurized Water Reactor. The following economic factors were considered: labor, materials, conversion of $UO_2$ to $U_3O_8$, and fuel charge difference. It was found that vibratory compacted rods at about 89% of theoretical density are economically equivalent to pelletized rods with pellet densities of 94% of theoretical (M.C.G.)

**11143** (CEND-153(Vol.I)(p.11-21)) FABRICATION TECHNIQUES FOR PACKED-POWDER FUEL ELEMENTS. J. J. Hauth (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

Techniques are being developed for fabrication of ceramic uranium fuels and plutonium-bearing recycle fuels. Emphasis was placed on packed-powder fuel elements. Fuel materials and compaction methods are described. (M.C.G.)

**11144** (CEND-153(Vol.I)(p.23-38)) PREPARATION OF OXIDE FUELS FOR VIBRATORY COMPACTION BY THE SOL-GEL PROCESS. D. E. Ferguson, O. C. Dean, and P. A. Haas (Oak Ridge National Lab., Tenn.).

The sol-gel process for preparing thorium oxide containing uranium oxide for vibratory compaction loading of fuel elements is described. The sol-gel route for oxide preparation offers the advantage of producing coarse, dense particles of either $ThO_2$ or $ThO_2-UO_2$ while employing a calcination temperature of only 1150°C. This process is suited for remotely preparing oxide containing $U^{233}$. (auth)

**11145** (CEND-153(Vol.I)(p.45-59)) PNEUMATIC VIBRATORY COMPACTION OF $UO_2$. R. C. Brayer and B. E. Murtha (Combustion Engineering, Inc., Nuclear Div., Windsor, Conn.).

It is shown that appreciable total fuel cycle cost savings are possible when vibratory compaction is utilized for loading and densifying $UO_2$ fuel elements. It was found that irregularly shaped $UO_2$ particles can be vibratory compacted, using pneumatic techniques, to densities in excess of 90% of theoretical and, in short lengths, as high as 93 to 94% theoretical density. It was also found that the particle size distribution will adjust itself to the optimum value for a given set of compaction parameters. This adjustment takes place at the expense of compaction time. Pre-densification appeared to be an important cost reduction step in the vibratory compaction cycle. (M.C.G.)

**11146** (CEND-153(Vol.I)(p.61-74)) VIBRATORY-COMPACTION STUDIES AT THE OAK RIDGE NATIONAL LABORATORY. W. S. Ernst, Jr., and R. L. Beatty (Oak Ridge National Lab., Tenn.).

Research and development progress on the vibratory compaction of oxide fuels is reported. The effects of vibration-energy characteristics on fuel density and the optimum particle-size distribution are discussed. (M.C.G.)

**11147** (CEND-153(Vol.I)(p.75-83)) PARTICLE SIZE RELATIONSHIPS IN THE PACKING OF $UO_2$. W. R. DeHollander (General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.).

The maximum density of $UO_2$ packing which was attained was obtained by choosing coarse, medium, and fine fractions separated by at least 6 sieve sizes each and generally located somewhere near the composition of 60% coarse, 20% medium, and 20% fines. Any improvement made in getting any fraction to pack to a higher density by itself is reflected in an increased density of a composite blend. (auth)

**11148** (CEND-153(Vol.I)(p.89-124)) COLD SWAGING $UO_2$ IN ZIRCALOY; THE EFFECT OF SOME PROCESS VARIABLES ON FUEL DENSITY AND SHEATH INTEGRITY. An Interim Report. M. A. Feraday (Atomic Energy of Canada Ltd., Chalk River, Ont.).

The fabrication of nuclear fuel elements containing vibratorily compacted fused $UO_2$, cold swaged inside Zircaloy, was further investigated. Vibration packed specimens were produced with $UO_2$ densities higher than 9.7 g/cm$^3$ using a vibratory electric hammer. From these, elements containing $UO_2$ with a density of 10.4 g/cm$^3$ were fabricated using only a 15% reduction in area by cold swaging. The use of relatively fine $UO_2$ powders, high initial vibrated densities, and small reductions in area by swaging is recommended. It was tentatively concluded that the sheathing of elements so produced is less susceptible to cracks, and to the precipitation of hydride platelets in a radial direction if severe hydriding occurs. (auth)

**11149** (CEND-153(Vol.I)(p.125-35)) FUEL ELEMENT FABRICATION BY COLD AND HOT SWAGING OF SPECIALLY PREPARED $UO_2$-POWDERS. F. Hofman, H. Kroll, and B. Liebmann (Nuklear-Chemie und-Metallurgie G.m.b.H., Wolfgang bei Hanau am Main, Germany).

Studies are being made to develop an economical process for the production of swaged $UO_2$ fuel elements. Powder preparation and powder compacting by hot and cold swaging are described. (M.C.G.)

**11150** (CEND-153(Vol.I)(p.137-47)) FABRICATION OF $UO_2$ FUEL ELEMENTS BY THE 'VIBSWAGE' PROCESS. E. I. Veil and R. H. Gale (Combustion Engineering, Inc. Nuclear Div., Windsor, Conn.).

Results obtained in fabrication of fuel rods by the "Vibswage" process are described. This process consists of an initial loading operation in which the tube is mounted on a small vibrator during loading to permit the attainment of densities up to about 85% of theoretical and the final densification, which is achieved by a single swaging pass to raise the density to above 90% of theoretical. Fused and ground $UO_2$ of three particle-size distributions was placed in stainless steel tubes. A comparison was made of density and elongation curves. (M.C.G.)

**11151** (CEND-153(Vol.I)(p.149-62)) VIBRATORY AND SWAGE COMPACTION OF SMALL DIAMETER STAINLESS STEEL CLAD FUEL RODS. R. L. Eichinger (Allis-Chalmers Mfg. Co., Milwaukee).

A program was pursued to develop more economical fuel processing techniques for the manufacturing of thin-wall, small-diameter rods for nuclear superheater fuel elements. Development studies on a cold swaging technique showed that a thin-walled, small-diameter stainless steel clad $UO_2$ fuel rod can be produced to predictable dimensions and density up to 88% of theoretical density using a mixture of 75 wt % arc fused and 25 wt % ceramic grade $UO_2$ powder by controlling the pre-swaged density with vibratory compaction and swaging reductions of 41 to 44%. (auth)

**11152** (CEND-153(Vol.I)(p.163-9)) COLD SWAGING OF URANIUM DIOXIDE. G. Frigerio (FIAT. Sezione Energia Nucleare, Turin).

Over 70 bars of many different diameters and thicknesses and 30 cm long were swaged to determine the importance of the cladding diameter-to-thickness ratio. For bars having $D_0/T$ ratios under 18, the density continued to increase with increasing reductions in area of fuel. For intermediate $D_0/T$ ratios from 18 to 26 the density reached a maximum after about 20% reduction in area and leveled off with further reductions. However, with values of $D_0/T$ of 29 and over, the density reached a maximum and then actually decreased with further reductions in area. Several reactor length bars were swaged using a semi-automatic feeding device and compared to results obtained by hand feeding. It was found that bars swaged with the feeding device had better surface finish and were straighter. Using the feeding device, stainless steel tubes with wall thicknesses as low as 15 mils were successfully swaged. Cold swaged densities up to 92 to 93% of theoretical are obtainable both with stainless steel and Zircaloy-2 with only 2 passes, a reduction of fuel area of less than 20%, a relatively low tube elongation and no intermediate annealing. The variation in density along the bars was on acceptable ±1% T.D. maximum; in some cases the deviations were only ±0.5%. Characterization of fused $UO_2$ powder and thermal conductivity of swaged $UO_2$ up to 500°C were studied. (auth)

**11153** (CEND-153(Vol.II)) SYMPOSIUM ON POWDER PACKED URANIUM DIOXIDE FUEL ELEMENTS, NOVEMBER 30,–DECEMBER 1, 1961. VOLUME II. (Combustion Engineering, Inc. Nuclear Div., Windsor, Conn.). Work performed under United States–Euratom Joint Research and Development Program. Contract [AT(30-1)-2379].

Nine papers and one abstract of a paper presented at the Symposium on Powder Packed Uranium Dioxide Fuel Elements are given. Topics covered include performance of powder packed fuel elements and special techniques. Separate abstracts were prepared for each of the 9 papers. (M.C.G.)

**11154** (CEND-153(Vol.II)(p.3-38)) IRRADIATION TESTING OF POWDER-CONTAINING FUEL ELEMENTS. E. A. Evans (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). (HW-SA-2419)

Irradiation tests on packed-powder fuels are reviewed. Materials studied included $ThO_2-UO_2$, $PuO_2-UO_2$, and $UO_2$. Both 19-rod cluster and nested tubular elements fabricated by vibrational compaction and swaging were tested. Photographs showing radiation effects are included. (M.C.G.)

**11155** (CEND-153(Vol.II)(p.39-65)) COMPACTED POWDER FUEL IRRADIATION STUDIES AT THE OAK RIDGE NATIONAL LABORATORY. W. C. Thurber (Oak Ridge National Lab., Tenn.).

Fuel rods containing nonsintered $ThO_2-UO_2$ and $UO_2$ were irradiated under a variety of experimental conditions. Maritime program irradiations, gas-cooled reactor program irradiations, fuel cycle program irradiations, and neutron-activation studies on ceramic fuel powders are described. Results are presented in graphs, photographs, and tables. (M.C.G.)

**11156** (CEND-153(Vol.II)(p.67-76)) THE PERFORMANCE EVALUATION OF COMPACTED POWDER $UO_2$ FUEL RODS. J. W. Lingafelter (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.).

A program for determining the performance characteristics of compacted powder $UO_2$ fuel is being conducted. Erosion, corrosion, and gas evolution tests and metallography of the $UO_2$ structure were carried out. Irradiation tests are being made. Results indicated that the performance of powder compacted fuel rods is at least as good as pellet type fuel rods. (M.C.G.)

**11157** (CEND-153(Vol.II)(p.77-99)) FAILURES OF $UO_2$ FUEL TUBES BY INTERNAL HYDRIDING OF ZIRCALOY-2 SHEATHS. G. R. Caskey, Jr., G. R. Cole, and W. G. Holmes (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.).

Fuel element failures occurred in five of the eight assemblies of Zircaloy-2-sheathed $UO_2$ fuel tubes and stainless steel-clad $UO_2$ tubes that were irradiated. They were first detected shortly after a reactor startup by the presence of fission product gases in the reactor system. No changes in coolant flow through the assemblies and no significant particulate contamination were associated with the failures. Nine failures were isolated by post-irradiation inspection: three were sheathed with stainless steel and six were sheathed with Zircaloy-2. Four of the failures of Zircaloy-2-sheathed tubes were identical in appearance and had occurred by brittle fracture of the outer Zircaloy sheaths. The mechanism of failure was tentatively established and is characterized by the following features: formation of a few highly concentrated deposits of zirconium hydride from a relatively small total quantity of hydrogen contained within the tubes; diffusion of the hydrogen down the thermal gradient from the hot $UO_2$-sheath interface toward the cold sheath-coolant interface; precipitation of delta zirconium hydride platelets in an oriented pattern determined by either an applied tensile stress or a previous plastic strain; and fracture along the path of the oriented hydride platelets. This failure mechanism is applicable to other Zircaloy components of a reactor system, such as process tubes and pressure tubes that are exposed at relatively low temperatures under an applied tensile stress. At high sheath temperatures attained in fuel elements operating under power reactor conditions this failure mechanism is believed to be less effective or inoperative. The two other Zircaloy-sheathed tubes contained defects at the ends of the tubes but the nature and cause of the defects were not established. The outer sheath of one of the stainless-steel-sheathed tubes was split longitudinally and defects were found in the welded end closure. Branching transgranular cracks, characteristic of stress-corrosion cracking, were observed in the end plug and in the sheath near the split. Initial failure was attributed to the defective welded closure but the subsequent fracture of the outer sheath was associated with the stress-corrosion effects. The other two failures of stainless-steel-sheathed tubes were not completely characterized. (auth)

**11158** (CEND-153(Vol.II)(p.101-14)) CONTROL OF HYDROGEN IN THE FABRICATION OF TUBULAR $UO_2$ FUEL ELEMENTS. W. G. Holmes (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.).

Moisture adsorbed on the pulverized $UO_2$ of a powder-packed fuel element can cause failure of the element during irradiation. Adsorbed moisture can be removed by vacuum drying the compacted fuel assembly at 300°C immediately before final welding. The gas and moisture content of the $UO_2$ is reduced by vacuum outgassing the pulverized $UO_2$ at 1000°C. However, moisture may be reabsorbed by the oxide during subsequent fabrication so that effective moisture control is best obtained by drying the core of the compacted element. The removal of moisture not only limits the amount of hydrogen that might enter the zircaloy sheathing, but reduces the volume of other gases, such as methane, that may form by reaction with impurities in the $UO_2$. (auth)

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**11159** (CEND-153(Vol.II)(p.115-29)) THE EXTRUSION OF URANIUM DIOXIDE; TECHNIQUE OF EXTRUSION. R. Hauser (Compagnie Industrielle des Combustibles Atomiques Frittés, Corbeville, par Orsay (Seine-et-Oise), France).

A study was made of the fabrication of cylindrical uranium dioxide rods and tubes by extrusion and sintering in cracked ammonia at 1650°C. Diameters of 8 to 15 mm and lengths up to 200 to 250 mm were obtained with good dimensional tolerances. Densities were usually above 95% of theoretical and no additives were added to the uranium dioxide. It was shown that the extrusion process could compete very favorably with the conventional pelletization process as far as economy is concerned. (auth)

**11160** (CEND-153(Vol.II)(p.131-4)) THE EXTRUSION OF URANIUM DIOXIDE. PHYSICO-CHEMICAL PROPERTIES OF EXTRUDED URANIUM DIOXIDE. A. Porneuf (Compagnie Industrielle des Combustibles Atomiques Frittés, Corbeville, par Orsay (Seine-et-Oise), France).

All the measurements of physico-chemical properties of extruded and of pelletized $UO_2$ indicated similar results for both products after sintering. Under irradiation conditions, it appeared that the diffusion coefficient for fission gases, $D_{1400}$, for extruded rods is at least as good as the same coefficient for pellets having the same density. (auth)

**11161** (CEND-153(Vol.II)(p.135-54)) EXTRUSION OF $UO_2$ AND $ThO_2$-$UO_2$ NUCLEAR FUELS. William J. O'Leary and Richard S. Miller (Allis-Chalmers Mfg. Co. Atomic Energy Div., Washington, D. C.).

The extrusion of long rods of $UO_2$ and $ThO_2$-$UO_2$ systems is discussed. It was found to be possible to produce 6-in. sintered extrusions of $UO_2$ whose physical characteristics could be compared with those of pressed pellets. Density, impurity content, oxygen-to-uranium ratio, ultimate compressive strength, relative thermal conductivity, relative thermal shock resistance, porosity, microstructure, surface finish, straightness, and modulus of rupture were determined. Mixed $UO_2$-$ThO_2$ extrusions were prepared successfully. (M.C.G.)

**11162** (CEND-153(Vol.II)(p.163-94)) ULTRASONIC FILLING OF TUBULAR CLADDING WITH CERAMIC FUEL POWDERS. William B. Tarpley and Richard Pheasant (Aeroprojects, Inc., West Chester, Penna.).

Direct cold compaction of powdered fuels within cladding materials, which offers economy in fuel element fabrication, particularly with reprocessed and enriched fuels is discussed. Ultrasonic vibratory filling of cladding tubes under low restraining pressures (well below one ton per square inch) was explored and found to be superior to both low frequency vibratory compaction and cold pressing, as well as to have certain advantages over the sintered pellet process. Three points of ultrasonic application were studied: axial coupling to bottom fuel tube, flexural coupling to side of tube, and axial activation of restraining load. Using combinations of these, the following materials were compacted to the indicated percentages of theoretical density: urania (fused, ground, sized) 92%; urania (ceramic grade) 67%; thoria (ORNL process, sized, blended) 92%; and alumina (ceramic grade) 63%. Still higher densities appear possible with ceramic grades, through investigation to optimize interaction between material properties and points of ultrasonic application. The ultrasonic technique, which permits easy isolation of the activated tubes, is particularly adaptable to reprocessed and enriched fuel powders which may require use of glove boxes or shielding. Powders of widely different density remain essentially homogeneous. No deformation of cladding was observed. (auth)

**11163** (DMIC-181) JOINING OF NICKEL-BASE ALLOYS. R. M. Evans (Battelle Memorial Inst. Defense Metals Information Center, Columbus, Ohio). Dec. 20, 1962. Contract AF33(616)-7747. 71p. $2.00 TS

Criteria for the successful fabrication of nickel alloys are presented. Fusion welding, resistance welding, and brazing are covered. The welding of dissimilar nickel alloys and repair welding are also discussed. Alloys covered include: Monel, Inconel, Nimonic alloys, Illium alloys, Hastelloys, René 41, Waspaloy, and M-252 alloy. (M.C.G.)

**11164** (EURAEC-412) SWAGING OF URANIUM DIOXIDE. Annual Report No. 2, July 1, 1961-June 30, 1962. G. Frigerio (FIAT. Sezione Energia Nucleare, Turin). July 31, 1962. Work Performed under United States-Euratom Joint Research and Development Program. Contract 059-61-7RDI. 64p. (FN-E-25)

The reproducibility of data obtained for the vibro-swaging process for $UO_2$ was studied. The fabrication process investigated was the following: pneumatical vibration (4 minutes duration) to reach a $UO_2$ density of approximately 84% of theoretical followed by a relatively small reduction of the fuel rod total area (approx. 18%) obtained by two passes through the swager without intermediate annealing. The Spencer fused $UO_2$ powder was used with the following ternary mixture: 67.5% (-6+20); 12.5% (-35+100); 20% (-200). More than one hundred stainless steel and Zircaloy-2 cladded rods of reactor length (125 to 190 cm) were fabricated. For both stainless steel and Zircaloy-2 rods the reproducibility of the $UO_2$ average density was (92.5 ± 0.5)% T.D. Spread of density values along the rod length referred to the average density was (+0.5-1.5)% T.D. or better. Spread of final active length was ±1.3 cm or better. The behavior of weldrawn stainless steel tubing was found to be as satisfactory as the behavior of the more expensive seamless tubing. In one lot of fused $UO_2$ the fragmentation behavior was found to be such that it was not possible to obtain densities higher than 90% of theoretical. A preliminary investigation of the use of ceramic grade powder and of ceramic grade-fused $UO_2$ mixtures for swaging annealing experiments furnished $UO_2$ densities too low (less than 80% T.D.) to be of interest as an alternative to vibro-swaging process of fused $UO_2$. A study of the influence of the diameter-to-thickness ratio on the cold swaging of Zircaloy cladding $UO_2$ rods confirmed that tubes with higher $D_0/T$ ratios rupture with fewer passes through the swager. No cracks in Zircaloy-2 tubes were observed for reductions of total area lower than 20%. Collateral work was performed on the swaged $UO_2$ bar testing. Main items were: fragmentation behavior of fused $UO_2$ during vibration and swaging and thermal conductivity of swaged $UO_2$. Typical data on fragmentation behavior of fused $UO_2$ vibrationally compacted to 84% T.D. and swaged to 92.6% T.D. are given. A "stationary" technique was chosen for measuring the thermal conductivity of swaged $UO_2$. The method required a known heat source situated in an axial position along the center of the swaged bar to insure a radial heat flux. Thermocouple measurements at various known distances from the center of the rod made it possible to calculate the thermal conductivity. Assuming as a comparison base the values reported by Deem and Lucks for $UO_2$ pellets, the thermal conductivity values for swaged $UO_2$ seemed to remain lower by approximately (25+0-10)% than the thermal conductivity values for pellets at the same density (90% T.D.) and at temperatures between 150 and 800°C. Additional studies were performed on the porosimetry of swaged $UO_2$, roughness of cladding internal surfaces, hardness of cladding,

and thermal cycling of swaged $UO_2$ rod samples between room temperature and 600°C. A preliminary analysis of economic potentials of swaged $UO_2$ fuel was performed by comparing a typical power plant core made up of pelletized fuel with nine different swaged cores. The maximum net saving, among the cases considered, amounted to approximately 4% of the entire core cost. The effect of variation of linear specific power, burnup level and cladding-to-fuel weight ratio were analyzed in the cost comparison study. The estimation of breakeven points showed that the burnup level is a more important variable than the linear specific power. (auth)

**11165** (GNEC-179) FABRICATION PROCESS DEVELOPMENT OF THE BONUS PROTOTYPE SUPERHEATER FUEL ASSEMBLY. Interim Report. (General Nuclear Engineering Corp., Dunedin, Fla.). July 10, 1961. Contract AT(11-1)-795. 71p.

Fabrication techniques were developed for component manufacturing and assembly of Bonus-type superheater fuel assemblies. The fabricating techniques were used to satisfactorily produce one generally acceptable prototype superheater fuel assembly. In all cases, the processes developed appear to be suitable for fabrication of the Bonus reactor superheater fuel assemblies on a production basis. Adequate fixturing and normal precleaning were required in order to produce acceptable braze joints. Stretch-forming of the clad tubes was reproducible. Castings, precision cast or sand type, were found to be economically advantageous as compared to solid geometry machining. Visual inspection of all braze joints was found to be possible. Helium leak and hydrostatic tests were satisfactorily performed. Dimensional control of all components and assemblies was found to be reasonable. Problem areas are: increase in fuel rod length, fuel shifting, and irregularities in the clad tube surface noted after the fuel rod brazing cycle; the presence of incomplete braze fillets on the under side of the shell assembly tube sheets; and incomplete brazing of two of the pressure tube ferrule joints. (auth)

**11166** (HW-SA-2527) WELDABILITY OF METALS. E. B. LaVelle and D. L. Hovorka (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). [Apr. 9, 1962]. Contract [AT(45-1)-1350]. 24p.

The important considerations related to weldability of metals and alloys are described. Characteristics inherent to the important metallic material families are described in as much detail as has substantial bearing on weldability. The information given should be ample to serve as a guide toward obtaining more details which would be essential for the "difficult to weld" metals. The general approach to welding metals and alloys is placed in a true perspective (what can be done, and what to guard against that might be adverse to the making of a satisfactory weld). A substantial bibliography is included. (auth)

**11167** (NP-12228) PRODUCCION DE PLACAS DELGADAS DE $UO_2$ INFORME NO. 71. (Production of Thin Plates of $UO_2$. Report No. 71). Helmut Koll and Antonio J. Carrea (Argentina. Comision Nacional de Energia Atomica, Buenos Aires). 1962. 28p.

The effect of some parameters on the fabrication of thin plates of $UO_2$ by the sintering process is studied. Compacting pressures of 0.25 to 2 ton/cm$^2$, temperatures from 1100 to 1400°C, and sintering times from 1 to 3 hrs were used to determine the optimum values of these parameters. An analysis of the effect of the lubricant during the compression showed that the results were improved by the substitution of polyethylene glycol types for steric types, as the former were more easily removed from the compact and did not attack the $UO_2$ during sintering. Fracture during compression and extraction was studied. The compression law for the powder was determined, and the validity of the Bal'shin law was proved. The furnace atmosphere is of importance to the sintered product. Two types of atmosphere were analyzed—neutral atmosphere during sintering with final reduction in hydrogen and slightly reducing atmosphere during the entire process. An analysis of the effects on the final density and porosity showed that adding 3% $H_2$ to Ar produced good density and a stoichiometric oxide in the final product. It was shown that density is not a sufficient measurement to evaluate the degree of sintering. Only the combined use of density and porosity give a good evaluation. The compression pressure has a great effect on the pore size and distribution in the sintered product. Best results are obtained with high pressures, which gives small uniformly distributed pores. A metallographic study was made to determine the relation between pore size and distribution and the process parameters. "Compact zones" were observed with mean diameter from 1 to 2 mm with very reduced porosity. These zones had better hardness and resistance to corrosion and chemical attack than the rest of the material. (tr-auth)

**11168** (TID-15756) GUEST CRITICAL POINT—ARE THE REQUIREMENTS FOR NONDESTRUCTIVE TESTING OF WELDS VALID? Jay Bland (Knolls Atomic Power Lab., Schenectady, N. Y.). [nd]. Contract [W-31-109-eng-52]. 5p.

Requirements for nondestructive testing of welds are discussed. The evaluation of discontinuities are described. Standards for welds are also discussed. (M.C.G.)

**11169** (Y-1409) SHORT-ARC WELDING OF HASTELLOY N (INOR-8). H. B. Harlan and V. B. Gritzner (Union Carbide Nuclear Co. Y-12 Plant, Oak Ridge, Tenn.). Aug. 17, 1962. Contract W-7405-eng-26. 25p.

Experiments were conducted to compare, evaluate, and determine if the shielded-inert-gas, consumable-electrode, short-circuit welding process would offer advantages over the shielded-inert-gas, tungsten-arc welding process in the welding fabrication of Hastelloy N (INOR-8) materials. Filler wire for all experiments using the shielded-inert-gas, consumable-electrode welding process failed to meet the weldability tests required for the shielded-inert-gas, tungsten-arc process. This filler wire had been obtained to accomplish nuclear quality weldments in construction of a molten salt reactor. Results of these experiments showed that ductile welds with no cracking or fissuring could be accomplished approximately eight times faster by the semi-automatic consumable-electrode process than when using the manual tungsten-arc process. However, porosity was found in all test experiments using the consumable-electrode process. This porosity could be controlled to meet the Unfired Pressure Vessel Code (Section VIII, Appendix IV, Porosity Charts, ASME Boiler and Pressure Vessel Code). (auth)

**11170** (AEC-tr-5604) SOME FEATURES OF THE SINTERING OF POWDERS OF REFRACTORY COMPOUNDS. G. V. Samsonov and M. S. Koval'chenko. Translated from Poroshkovaya Metal., Akad. Nauk Ukr. SSR, 1: No. 1, 20-9 (1961). 12p.

Two methods of preparing refractory compound parts comprise (1) pressing bars from powder and then sintering them and (2) hot pressing (simultaneous pressing and sintering). These two methods are studied and compared with similar processes used in sintering metal powders. $TiB_2$, $CrB_2$, and $TiB_2-CrB_2$ were studied in the first method,

while WC and $Mo_2C$ were used in the second method. (D.L.C.)

**11171** (EURAEC-330) WELDING OF VERY THICK STEELS. Quarterly Report No. 2, January 1 to March 31, 1962. (Soudometal, S. A., Brussels and Ghent. Rijksuniversiteit). Work Performed under United States–Euratom Joint Research and Development Program. Contract 042-61-9-RDB. 152p. A translation.

Research and development during the period were devoted to studies concerning plastic strain embrittlement, effects of the Mn–Si ratio in weld filler products, properties of filler products alloyed with Mo and Ni–Mo alloys, impact strength variation in thick joints, hot cracking in filler products, cracking characteristics of base metals and filler products, and ductile-brittle transition in SOUDOTENAX 56 steel. (J.R.D.)

**11172** (EURAEC-391) A STUDY OF THE RESIDUAL STRESSES RESULTING FROM THE RISING VERTICAL WELDING PROCESS. Quarterly Report No. 2, April 1–June 30, 1962. (ARCOS, S. A., Brussels). Work Performed under United States— Euratom Joint Research and Development Program. Contract 053-61-12-RDB. 68p. A translation.

Reception tests were carried out on the saw required for cutting out samples intended for the determination of residual stresses. Temperature and deformation measurements were made on test sample No. 4. Test samples No. 5 and No. 1 were prepared and welded. Studies were made of a more accurate way of temperature registration and of a method for determining thermal stresses according to the thickness of the plate. (M.C.G.)

**11173** (EURAEC-446) STUDY OF RESIDUAL STRESSES GENERATED BY THE RISING VERTICAL WELDING PROCESS. Quarterly Report No. 3, July 1 to September 30, 1962. (Arcos, S. A., Brussels). Work Performed under United States–Euratom Joint Research and Development Program. Contract 053-61-12-RDB. 66p. A translation.

The test program for specimen #1 including temperature corrections and determinations of deformation, residual stresses, and penetration was completed. Completion of the test program for specimen #4 including temperature corrections and determinations of residual stresses and penetrations is also reported. In other work the electroslag welding of specimens 6 and 7 is reported, and comparison data on temperature recording using a modified thermocouple placement are presented. (J.R.D.)

**11174** PRODUCTION OF GRAPHITE-COATED PARTICLES OF NUCLEAR FUEL BY THE FLUIDIZED BED PROCESS. F. Benesovsky and E. Rudy (Metallwerk Plansee A. G., Reutte, Tyrol, Austria). Metall, 16: 957-61(Oct. 1962). (In German)

For the production of graphite-coated fuel particles, a semi-automatic high-temperature fluidized bed installation was developed. It permits graphite layers to be deposited from the pyrolytic decomposition of hydrocarbons at temperatures up to 2200°C. The properties of the particles were discussed on the basis of microscopic studies. The stability and fission product retention of the fuel particles were considered. (tr-auth)

**11175** INVESTIGATIONS ON THE STABILITY BEHAVIOR OF METAL BONDING ADHESIVES WITH RESPECT TO VARIOUS ENVIRONMENTAL INFLUENCES. H. Winter and H. Meckelburg (Deutsche Forschungsanstalt für Luft- und Raumiahrt e. V., Brunswick). Metall, 16: 962-74(Oct. 1962). (In German)

The stability behavior of metal bonding adhesives of Al, stainless steel, and Ti was investigated for environmental stresses of thermal, climatic, and corrosive types. Because of the property modifications of the synthetic high polymer adhesives, a strength reduction or damage of the adhesive compound is found. Whereas the heat stability can be limited, the climate stability is, in general, completely satisfactory. The corrosion stability can be increased for normal conditions. On the basis of multiplicity of the corrosion processes, each application necessitates corresponding research. The experimental results reported on the stability of metal bonding adhesives yielded insight on the physical and chemical patterns in the environmental stresses of bonding compounds. (tr-auth)

**11176** COLD ENCAPSULATION OF COBALT. Thomas Horne (Curtiss Wright Corp., East Paterson, N. J.). Nucleonics, 21: No. 2, 72-4(Feb. 1963).

The method developed for use with the 1.3 megacurie cobalt-60 irradiator was described in detail. A stainless-steel inner encapsulation was fitted with an outer jacket of aluminum. The cost per unit of source was determined and found to be considerably less than the cost of processes now in use. (C.E.S.)

**11177** NUCLEAR ENGINEERING MATERIALS POWDER METALLURGY IMPROVES IMPACT EXTRUSIONS FOR FUEL ELEMENTS. Precision Metal Molding, 20: No. 4, 37p(Apr. 1962).

Improved properties in Al, particularly at high temperatures, result from combining the powder metallurgy and impact extrusion processes. Slugs compacted from Al powder and then impact-extruded show strength higher than that of wrought alloys. Parts made by this method also have high thermal conductivity. In nuclear applications, the material shows low neutron absorption, and resistance to highly corrosive organic coolants such as terphenyl. The improved properties are attributed to dispersion-strengthening by the $Al_2O_3$ present in the slugs. Finned tubes made in this way, and filled with $UO_2$ pellets are used to build fuel elements. Typical tubes are 5 ft long with inner diameter 0.305 in. and 0.03 in. wall thickness. The ductility of the tubes is indicated by the twist of 45° per ft effected after impacting. (Atomdokumentation, 4: No. 13, Nov. 1962)

**11178** PREPARATIONS OF Hf AND Ge FOILS FOR NUCLEAR STUDIES. O. P. Klyucharev, A. D. Nikolaichuk, and T. S. Nazarov (Inst. of Physics and Tech., Khar'kov). Ukr. Fiz. Zh., 7: 1027(Sept. 1962). (In Ukrainian)

Preparation of 1 to 7 $\mu$ Hf and Ge foils by thermal dissociation of hafnium and germanium iodides is described. (R.V.J.)

## Properties and Structure

**11179** (AERE-M-1149) SUMMARY OF THE CREEP PROPERTIES OF A MAGNESIUM–CADMIUM ALLOY USED FOR NEUTRON CHOPPER ROTORS. P. A. Egelstaff and L. A. Wraight (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). Dec. 1962. 14p.

Results are summarized of creep tests made at Fulmer Research Institute under A.E.R.E. contract on a magnesium–cadmium alloy. From these results, the maximum stress permitted in the design of neutron chopper rotors made from this alloy is deduced to be 9 tons/in.$^2$ for a life of 3,000 hours. The possibility of using other alloys which might be capable of a greater rating is also considered. (auth)

**11180** (ANL-FGF-337) ALLOY CHEMISTRY OF TRANSITION ELEMENTS. M. V. Nevitt (Argonne National Lab., Ill.). Mar. 30, 1962. Contract W-31-109-eng-38. 120p. (UAC-6374)

A review of the structure types in binary alloy $\sigma$, $\mu$, and $\chi$ phases of transition elements is presented. Information is included on ternary alloys in which the P and R intermediate phases appear also. It is noted that proceeding from the A-component end, the phases occurring at fixed stoichiometric ratios have structures such as at $A_3B$ the $Cr_3O$-type; at $A_2B$ the $Ti_2Ni$-type (eta-carbide), the $MoSi_2$-type (C11B), and the $CuAl_2$-type (C16); at the equiatomic composition the CsCl-type (B2); at $AB_2$ the $MgCu_2$-type C15), the $MgZn_2$-type (C14), the MgNi-type (C36), and another group of $MoSi_2$-type phases; at $AB_3$ a group of close-packed ordered CN12 structures; and at the $AB_5$ composition the $UNi_5$-type ($C15_b$) and the $CaCu_5$-type ($D2_d$). The emphasis in the review is on structure relations, occurrence regularities, and the effects of atomic sizes and electronic factors. (J.R.D.)

**11181** (ANL-FGF-345) THE URANIUM MONOCARBIDE–PLUTONIUM MONOCARBIDE SYSTEM. S. Rosen and M. V. Nevitt (Argonne National Lab., Ill.). May 2, 1962. Contract [W-31-109-eng-38]. 9p. (UAC-6408)

The (U,Pu)C phase field of the U–Pu–C ternary system for temperatues below 635°C was constructed from metallographic and x-ray diffraction data. Uranium monocarbide formed a complete series of solid solutions with plutonium monocarbide. The (U,Pu)C phase was stoichiometric as regards its carbon content in a composition range from 0 to 35 at.% Pu. With a further increase in Pu content it deviated from ideal stoichiometry toward greater metal to carbon ratios to form the defect (U,Pu)C phase. Pu expanded the unit cell of the monocarbide over the composition range in which it retained its stoichiometric character. In the region of the defect structure the lattice parameter decreased with increasing Pu content, the extent of the decrease being dependent upon the carbon content. Metallographic observations on cast alloys showed that a transition occurs in the microstructures between U-rich alloys which show a homogeneous carbide phase and Pu-rich alloys which show a cored carbide phase. (auth)

**11182** (AROD-3394.1) DISLOCATION MOBILITY AND INTERACTIONS IN HIGH PURITY MAGNESIUM. Interim Technical Report No. 1. M. J. Roblin and G. S. Ansell (Rensselaer Polytechnic Inst., Troy, N. Y.). Dec. 15, 1962. Contract DA-009925001. 138p.

Transmission electron microscopy was utilized to study the role of crystal structure upon slip as a plastic deformation process in high purity polycrystalline thin foils of magnesium. The effect of stress on the mobility of wholly contained basal dislocations was investigated, using sequential and cine photography. A relationship was derived for such dislocations moving through the lattice with a constant velocity and it was utilized to show that the applied stress is not related to the velocity as reported by previous investigators. It was suggested that a stress velocity relationship should exist only between the lattice resistance stress and the velocity. A method of determining the lattice resistance stress was put forth for a specialized case of a moving dislocation array. An example of such a case was shown, and the lattice resistance stress calculated for a particular dislocation velocity. The operating slip planes were investigated by observation of moving dislocations or their traces, coupled with selected area diffraction. Five different slip planes were identified and the burgers vectors were deduced from crystallographic considerations. The diffraction patterns which were solved for the determination of the operating slip planes provided information about the plane of the foil surface. An unusual recrystallization texture was noted, and the information was plotted on a standard stereographic triangle. Simple twist boundaries were observed which provided information about the stacking fault energy of magnesium. The frequency of cross-slip correlated well with the estimate of the stacking fault energy, and on this basis the possible cross-slip plane for several slip planes was deduced. Dislocation tangles were observed in many other metals and generally occur in thicker sections of the foils where the image forces are reduced. This was found to be true for magnesium, and while the tangles complied with the observations of others, they were not observed to form upon straining, but existed in the foils after recrystallization. Grain boundary sliding was studied primarily by cine photography techniques. A model for sliding is presented on the basis of the observations made in this thesis. The proposed model correlates well with the quantitative studies of the phenomena made by other investigators. (auth)

**11183** (AWRE-O-61/62) THE EQUATION OF STATE OF URANIUM IN THE CRITICAL REGION. E. Morris (United Kingdom Atomic Energy Authority. Weapons Group. Atomic Weapons Research Establishment, Aldermaston, Berks, England). Dec. 1962. 65p.

The results of the shock wave experiments carried out by Skidmore are discussed with respect to the reactor accident problem. A comparison between Brout's predictions and the experimental data is made, and a modified application of the principle of corresponding states is suggested. A version of the Bethe and Tait method for calculating fast reactor accidents is given. (D.L.C.)

**11184** (BNL-758) GRAPHITE PROBLEMS IN AIR-COOLED REACTORS. Donald G. Schweitzer and Robert M. Singer (Brookhaven National Lab., Upton, N. Y.). Oct. 1962. Contract [AT-30-2-GEN-26]. 8p. (BNL-T-281)

Oxidation, radiation-induced dimensional expansions, and accumulation of stored energy are three major problems affecting long-term use of graphite in air-cooled reactors. Frequent low-temperature annealing eliminates these problems and may extend the lifetime of the graphite indefinitely. (auth)

**11185** (D1-82-0169) THE ANALYSIS OF FRACTURE SURFACES BY ELECTRON MICROSCOPY. Corey McMillan and Regis M. N. Pelloux (Boeing Scientific Research Labs., Seattle). May 1962. 39p.

The different observations made on the fracture surfaces of steels and aluminum alloys resulting from brittle, ductile, fatigue, and intergranular fractures are reviewed and illustrated. The investigation of the intergranular fracture of A.I.S.I. 4340 steel parts during service is described and the causes of fracture are discussed. Suggestions are made for the use and development of the techniques and findings of electron microfractography in the investigation of the causes of service failures. (auth)

**11186** (DRI-2080) RESEARCH ON THE SAMARIUM-TYPE INTERMEDIATE PHASES OF INTRA-RARE-EARTH BINARY SYSTEMS. Technical Report No. 1. J. F. Nachman, C. E. Lundin, and G. P. Rauscher, Jr. (Denver. Univ. Denver Research Inst.). Jan. 1963. Contract Nonr-3661(02). 44p.

The existence of a samarium-type phase in intra-rare-earth alloys, consisting of a light and a heavy rare earth, was verified in the La-Gd, La-Y, Ce-Y, and Nd-Y systems. X-ray diffraction and metallographic techniques were em-

ployed to establish the composition limits of the single and two-phase regions. Precise lattice parameters and x-ray densities for the alloys were calculated from data obtained with the Debye-Scherrer camera. A hardness survey of the intra-rare-earth alloys is also presented. (auth)

**11187** (EURAEC-447) THE DEVELOPMENT OF A NEW DETERMINATION OF THE DUCTILE-BRITTLE TRANSITION TEMPERATURE. Quarterly Report No. M-62-1197-26150, July 1, 1962 and September 30, 1962. H. C. van Elst (Netherlands. Nijverheidsorganisatie, TNO, The Hague). Oct. 19, 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 068-61-11-RDN. 56p.

Research was conducted to develop a test method which will give the same information on brittle fractures as the Robertson test, but which will require only small specimens. Running fractures in steel in a Robertson apparatus were studied using streak photography, and the stress configuration of the moving fractures was recorded by photoelastic methods. A stepwise mechanism of fracture propagation is proposed in which the stress waves create microcracks ahead of the fracture. The creation of similar stress waves in a Hopkinson pressure bar by explosives was studied. The damping of stress waves in small cylindrical specimens was measured. (D.L.C.)

**11188** (EURAEC-485) THE EFFECT OF RADIATION ON THE DUCTILE-BRITTLE TRANSITION IN PRESSURE VESSEL STEELS. Quarterly Report No. 7, July 1–September 30, 1962. E. Anderson, W. Bollmann, D. King, M. Malone, and J. Spreadborough (Battelle Memorial Inst. International Div., Geneva). Oct. 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 041-60-12-RDS. 39p.

The progress made in the evaluation of the tensile properties of Armco iron is reported. The phenomenon of Lüders bands was further studied and the previously proposed model was elaborated. The activation volume and activation energy for Lüders propagation were calculated from rate change experiments. For one series of specimens, the volume decreases from 110 to 50 $b^3$ with decrease from 296 to 219°K; the energy also decreases from 0.675 to 0.35 ev. The activation volume for flow for this same series varies from 633 $b^3$ at 296°K to 70 $b^3$ at 219°K. Some Lüders profiles were also measured and it seems that the shape of the band front depends on the grain size. Attention was paid to the twinning incidence in specimens tested at low temperatures. Twinning is a function of grain size and temperature, increasing with decrease in temperature, but is apparently not a function of the transition temperature. The stress to initiate twinning depends on grain size, and is constant for a constant grain size. (auth)

**11189** (GAMD-2638) HELIUM INLEAKAGE THROUGH POROUS-WALLED FUEL ELEMENTS. R. F. Turner (General Atomic Div. General Dynamics Corp., San Diego, Calif.). Nov. 21, 1961. Contract AT(04-3)-314. 9p.

Theoretical and experimental studies indicated that the effective permeability coefficient for graphite is lowered by a helium stream in-sweeping through the graphite pores. This phenomenon was considered in the design of HTGR fuel elements. A portion of the helium gas which is drawn into each fuel element as a purge stream may enter through porous wall sections, supplementing the purge gas entering at the top of each fuel element. The purge stream leaves each fuel element through a header system which carries the purge gas to an external fission product trap. The flow rate through the trapping system determines the upper limit of the average in-leakage through the fuel element walls. In the case of the HTGR, a graphite having a helium permeability of 1.1 $cm^2$/sec at 350 psia and 700°F (approximately 0.1 $cm^2$/sec at 14.7 psia, 70°F) would result in 100% of the purge flow entering through the wall sections of the fuel element. A lower permeability graphite, with most of the purge flow entering at the top of the fuel element appeared to be more desirable for maintaining optimum purge flow conditions. (auth)

**11190** (IS-477) ELECTRICAL RESISTIVITY OF RARE-EARTH ALLOYS. F. A. Smidt, Jr. and A. H. Daane (Ames Lab., Ames, Iowa). [June 5, 1962]. Contract [W-7405-eng-82]. 27p.

Resistivities of solid solution alloys in the systems Gd–Lu, Tb–Lu, Gd–Er, and Y–Lu were measured at 4.2 to 320°K to determine the behavior of the resistivity in alloy systems with magnetic phenomena arising from localized magnetic moments. A large contribution to the residual resistivity is caused by the random distribution of these localized moments through the lattice. An analysis of the lattice resistivity of the metals shows large variations across the heavy rare-earth series which are possibly correlated with the change of c/a ratio of the metals and the attendent changes in the Fermi surface geometry. (auth)

**11191** (NP-12483) REFRACTORY MATERIALS RESEARCH. Ninth Quarterly Progress Report, October 1, 1962 to December 31, 1962. G. M. Kibler, T. F. Lyon, M. J. Linevsky, and V. J. DeSantis (General Electric Co. Flight Propulsion Lab. Dept., Cincinnati). Dec. 31, 1962. Contract AF33(616)-6841. 46p.

Concurrently with the design and fabrication of apparatus modifications to be used in studying evaporation of borides, an additional series of measurements of the rate of $N_2$ effusion from a Knudsen cell containing HfN was made, and two additional series of measurements in the Ta–N high $N_2$ content region were also completed. The HfN results provide further evidence that the orifice effects noticed are related to diffusion limitations rather than to a non-unit evaporation coefficient. Nitrogen pressures computed from effusion rates from Ta–N compositions were found to differ widely from one series to another in the region of 33 to 48 at. % $N_2$. No satisfactory explanation can be given, at present, for this behavior. In matrix isolation studies of the infrared spectra of vapor species over $ZrO_2$, spectra were obtained in solid Ar matrices, and several fundamental frequencies of $ZrO_2$ and ZrO molecules were identified. Resonance line absorption measurements of both the B and Zr atom lines in the vapor over pure $ZrB_2$ were made and absorption measurements over the pure elements are now proceeding. The normal spectral emissivities of TaN and of pyrolytic graphite at 1600 to 2400°K were measured and normal total emissivities were computed. (auth)

**11192** (ORNL-3299) AN INVESTIGATION OF THE INSTANTANEOUS AND CREEP BUCKLING OF INITIALLY OUT-OF-ROUND TUBES SUBJECTED TO EXTERNAL PRESSURE. J. M. Corum (Oak Ridge National Lab., Tenn.). Jan. 30, 1963. Contract W-7405-eng-26. 84p.

A method was developed for predicting the instantaneous and creep buckling characteristics of initially out-of-round tubes subjected to lateral external pressure. Both the critical pressure causing collapse and the deformation of a tube at the instant of impending collapse may be determined by the method. Stress distributions represented by segments of the short-time stress-strain curve for the tube material were used to determine the instantaneous

buckling characteristics. For creep buckling, approximate stress distributions derived from isochronous stress-strain curves were utilized, and the resulting collapse predictions were observed to become increasingly conservative with time. The method was used to predict the instantaneous and creep buckling characteristics of a series of 8.0-in.-OD type 304 stainless steel tubes that were collapsed at a temperature of 1200°F. Although the number of experimental tests did not represent an adequate sample, the instantaneous collapse pressures agreed closely with the predicted values, and the time-dependent collapse test results substantiated the observation that the theoretical creep-collapse predictions become increasingly conservative with time. It was found that a small initial out-of-roundness significantly reduces the resistance of a tube to collapse. (auth)

**11193** (TID-17635) SORPTION OF GASES ON METAL SURFACES IN ULTRAHIGH VACUUM. Quarterly Report No. 3, August 15 to November 15, 1962. R. A. Pasternak and Bjoern Bergsnov-Hansen (Stanford Research Inst., Menlo Park, Calif.). Nov. 28, 1962. Contract AT(04-3)-425. 11p.

An experimental unit was developed for studying metal films in ultrahigh vacuum. Procedures for sorption measurements and calibration are described. (D.L.C.)

**11194** (TRG-Report-408) MIXED OXIDES BASED UPON CaO AND BeO—THEIR SIGNIFICANCE IN BERYLLIUM CORROSION AND BeO/$UO_2$ REACTOR FUELS. I. F. Ferguson (United Kingdom Atomic Energy Authority. Reactor Group, Springfields, Lancs, England). Sept. 11, 1962. 6p.

Mixed oxide structures based on both lime and beryllia are considered and compared with those described in the literature in an effort to decide whether these structures could be responsible for the corrosion behavior difference in Be and Be–Ca systems. Structural considerations appear to make the existence of $BeUO_4$ and $BePuO_4$ impossible. This precludes one form of interaction between fuel and matrix in dispersion-type nuclear fuels based on beryllia. (J.R.D.)

**11195** (UCRL-9536) CRYSTAL STRUCTURE OF $\beta'$ $Cu_{0.75}Al_{0.25}$. G. Thomas and M. C. Huffstutler, Jr. (California. Univ., Berkeley. Lawrence Radiation Lab.). [Apr. 20, 1962]. Contract [W-7405-eng-48]. 1p.

The crystal structure of the martensitic $\beta'$ phase of the eutectic alloy in the Cu–Al system was determined by electron and roentgen defraction to have the lattice constants a = 2.57 Å and c = 4.21 Å. These constants are compared with those determined by Hunger and Dienst. (D.L.C.)

**11196** (UCRL-10152) ON THE PLASTIC BEHAVIOR OF POLYCRYSTALLINE AGGEGATES. John E. Dorn and Jim D. Mote (California. Univ., Berkeley. Lawrence Radiation Lab. . Mar. 1962. Contract W-7405-eng-48. 89p.

The status of knowledge concerning single crystals and bicrystals is reviewed. Information and deductions on the behavior of polycrystalline aggregates suggest that the flow stresses are only a few times as great as those for single crystals and are independent of grain size Data and information are also presented to show that deformation in crystals is highly localized. It is noted that the plastic behavior of polycrystals cannot be exclusively deduced from single crystal data, and more effort is required toward the understanding of auxiliary deformation in polycrystalline metals. (J.R.D.)

**11197** (UCRL-10435) DEFORMATION AND FRACTURE OF POLYCRYSTALLINE LITHIUM FLUORIDE (thesis). William D. Scott (California. Univ., Berkeley. Lawrence Radiation Lab.). Sept. 14, 1962. Contract W-7405-eng-48. 77p.

Techniques for forming polycrystalline LiF from the melt and for fabricating test specimens were developed and evaluated using single-crystal LiF as a control. Large-grain polycrystalline specimens tested in four-point loading always showed some plastic deformation (0.076 to 0.798%) before fracture, but the plastic flow was sharply reduced from that of single crystals. An etch was developed revealing dislocations on all crystallographic faces of LiF. Details of plastic deformation in polycrystalline material were investigated. Deformation was inhomogeneous among the grains of an aggregate because of differences in orientation with respect to the applied stress, also within individual grains because of interactions between adjoining grains. Grain boundaries were barriers to slip, but stresses resulting from slip in one grain were transmitted to neighboring grains and often caused local deformation near the boundary. Because of local stresses, local slip systems operated although the resolved shear stresses on them from the applied load were below the critical yield stress. In one case, slip occurred on an (010) plane. Three-grain junctions were areas of high residual stress. Fractures originated at boundaries at or near 3-grain junctions, not as a result of inherent boundary weakness but rather because of high stresses developed at the boundary. A quantitative expression for fracture originating in a slip band was applied to one type of fracture. (auth)

**11198** (UCRL-10498) DISLOCATION CONCEPTS OF STRAIN RATE EFFECTS. John E. Dorn and Frank E. Hauser (California. Univ., Berkeley. Lawrence Radiation Lab.). Sept. 4, 1962. Contract W-7405-eng-48. 30p.

Whereas von Karman and Taylor independently based their analyses for plastic wave propagation on the deformation concept which assumes the deformation stress is exclusively a function of the plastic strain, Malvern believed that a viscoelastic type of behavior is more realistic, assuming the flow stress is a function of the strain rate as well as the strain. It is shown that both concepts are substantially correct under appropriate circumstances. This thesis is upheld not only in terms of experimental evidence but also in terms of deductions arrived at from elementary dislocation theory. (auth)

**11199** (UCRL-13061) THERMAL CONDUCTIVITY AND EXPANSION OF TWO PLATINUM ALLOYS. Final Report to Lawrence Radiation Laboratory. W. T. Engelke and C. D. Pears (Southern Research Inst., Birmingham, Ala.). Dec. 7, 1962. Contract [W-7405-eng-48]. 39p.

The thermal conductivity from 500 to 2500°F and the thermal expansion from 1900 to 2500°F were determined for a platinum–5% ruthenium alloy and a platinum–40% rhodium alloy. The thermal conductivity of the platinum–5% ruthenium alloy decreased gradually from 450 Btu/hr/$ft^2$/°F/in. at 500°F to 350 Btu/hr/$ft^2$/°F/in. at 2500°F, which was below the thermal conductivity of both constituents. The thermal conductivity of the platinum–40% rhodium decreased from 960 Btu/hr/$ft^2$/°F/in. at 500°F to 680 Btu/hr/$ft^2$/°F/in. at 2500°F which was considerably higher than that of pure platinum and lower than for pure rhodium. The coefficient of thermal expansion of the platinum–5% ruthenium was $4.75 \times 10^{-6}$ in./in./°F at 2000°F. The thermal expansion of platinum–40% rhodium was $6.3 \times 10^{-6}$ in./in./°F at 2000°F. For both materials, the expansions were about 10% lower than those of pure platinum. (auth)

**11200** (USNRDL-TR-599) THERMAL DIFFUSIVITY AND HEAT CAPACITY MEASUREMENTS AT LOW TEMPERATURES BY THE FLASH METHOD. O. Makarounis and R. J. Jenkins (Naval Radiological Defense Lab., San Francisco). Nov. 19, 1962. 24p.

A method for measuring heat capacity and thermal diffusivity of solid materials from −180 to +200°C is described. A high intensity short duration light pulse is absorbed in the front surface of the specimen and the resulting temperature rise of the rear surface is measured by a thermocouple, displayed on an oscilloscope and photographed by a Polaroid Land camera. From the shape and magnitude of the temperature traces thus obtained, the thermal diffusivity and heat capacity of the specimen are determined. Thermal properties of aluminum alloy No. 2024 and single crystal magnesium oxide were determined with this method over the temperature range from −180 to +200°C. (auth)

**11201** (AEC-tr-5598) ANALYSIS OF THE SYSTEMS OF HIGH MELTING CARBIDES ALONG WITH CONTRIBUTIONS TO THE PROBLEM OF CARBON MELTING. C. Agte and H. Alterthum. Translated for Ames Lab., Ames, Iowa from Z. Tech. Physik, 11: 182-91(1930). 13p.

Melting points were determined for the carbides: ZrC, 3805 ± 125°K; NbC, 3770 ± 125°K; $Mo_2C$, 2960 ± 50°K; MoC, 2965 ± 50°K; HfC, 4160 ± 150°K; TaC, 4150 ± 150°K; $W_2C$, 3130 ± 50°K; and WC, 3140 ± 50°K. Metallographic microsections are given for melted carbides and carbide systems. Melting points were also studied for the following carbide systems: TaC−$W_2C$, NbC−$W_2C$, ZrC−$W_2C$, NbC−TaC, NbC−ZrC, TaC−ZrC, TaC−HfC, and TaC−ZrC−NbC. Fusion experiments on carbon in TaC crucibles are reported. (D.L.C.)

**11202** (AEC-tr-5621) FUNDAMENTAL OBSERVATIONS ON THE EFFECT OF ELECTROSTATIC PHENOMENA ON THE FLUIDIZATION PROCESS. Janusz Ciborowski and Andrzej Wlodarski. Translated for Argonne National Lab., Ill., from Chem. Stosowana, 3: 339-51(1959). 11p.

Disturbances observed in a bed of sand, which, generally, is a material that fluidizes well, are described. The disturbances, accompanied by electrostatic phenomena, lie in the inability to reach a fluidized state or in the start of fluidization at above normal velocities. They are also manifested by the appearance of the tendency toward channeling and by formation of static layers of sand grains which make direct contact of the fluidized bed with the walls of the apparatus impossible. (auth)

**11203** (EURAEC-434) RESEARCH ON THE THERMAL EXPANSION OF $UO_2$, $PuO_2$, AND $UO_2-PuO_2$. Special Report No. 6. J. M. Leblanc and H. Andriessen (Brussels. Centre d'Etude de l'Energie Nucléaire and Société Belge pour l'Industrie Nucléaire, Brussels). June 1962. Work Performed under United States−Euratom Joint Research and Development Program. Contract 27-60-7RDB. 33p. A translation of Blg-101.

Activities in a program to determine how the coefficient of thermal expansion in mixed $PuO_2-UO_2$ systems varies with $PuO_2$ content are reported. Data are included from tests performed on stoichiometric and nonstoichiometric $PuO_2$ and $UO_2$ compositions to determine the points of reference for the dilatometric investigation and to help in establishing equilibrium diagrams for these systems. (J.R.D.)

**11204** (EURAEC-444) RESULTS OF WORK CARRIED OUT FROM JULY 1 TO SEPTEMBER 30, 1962. Quarterly Report No. 2. (Compagnie Pechiney, Paris). Oct. 31, 1962. Work Performed under United States−Euratom Joint Research and Development Program. Contract 067-62-RDF. 62p. A translation.

A series of thermal treatments is reported in which alloy behavior is observed in terms of temperatures used and additive effects. Included are results of phase studies of V−Zr, Ni−Zr, unalloyed Zr, and Ni alloys. Results of micrographic examinations of these alloys are also included. (J.R.D.)

**11205** BARYTE AS RADIATION PROTECTION MATERIAL. Hans Goetting. At. Strom, 8: 67-70(Oct. 1962). (In German)

The properties of baryte that make it a good radiation protection material are reported, and concrete prepared with it is compared with pyrite and magnetite concretes. (J.S.R.)

**11206** THE DIFFUSION OF LITHIUM IN TUNGSTEN. H. M. Love and G. M. McCracken (Queen's Univ., Kingston, Ont.). Can. J. Phys., 41: 83-9(Jan. 1963).

Diffusion of lithium-7 through tungsten at temperatures around 1500°K is investigated by directing a current of lithium atoms against the face of a tungsten ribbon and detecting the ionized atoms that diffuse through with a mass spectrometer-cutting off the atom beam causes the ion current to fall, the rate of decay yielding the diffusion coefficient $D = D_0 \exp(-e/kT)$, where $e$ is 1.8 ± 0.2 ev, $D_0 = 5\ cm^2/sec$, and T is the absolute temperature. (D.C.W.)

**11207** EXPERIMENTAL STUDY OF TUNGSTEN ENTHALPY OF THE TEMPERATURE RANGE FROM 350° TO 2000°C. V. Y. Chekhovskoi, B. Y. Shumyatskii, and K. A. Yakimovich. Inzh.-Fiz. Zh., Akad. Nauk Belorussk. SSR, 5: No. 10, 13-18(Oct. 1962). (In Russian)

Experimental data on tungsten enthalpy over the temperature range from 350 to 2000°C are presented. A resistance furnace with a tungsten heater and a massive copper calorimeter in an isothermal jacket are used in the experiments. The temperature of the sample is measured by platinorhodium-platinum thermocouples and an optical pyrometer. The temperature changes of the calorimeter are measured by two platinum resistance thermometers. The degree of uncertainty in the results in estimated at ±(0.6 to 0.9) per cent, depending on the temperature measurement method used. (auth)

**11208** APPLICATION OF AUTORADIOGRAPHY TO THE INVESTIGATION OF THE STRUCTURE OF ALLOYS. M. Radwan (Inst. for Nuclear Research, Polish Academy of Sciences, Warsaw). Isotopen Tech., 2: 270-5(Sept. 1962). (In German)

The structure of alloys can be tested by the addition of radioactive nuclides to the melt or by the production of radioisotopes with neutron irradiation. With this method one can obtain data on the distribution of elements in the individual structure constituents. The decisive criterion for the utility of the method is its sensitivity. This sensitivity is dependent on the specific activity of the radioisotopes present. In this connection, the sensitivities for the case of radioisotope introduction into the melt and the case of activation are given. Economically the calculation for the exposure time for the autoradiogram is of great significance. Therefore the principles for calculating exposure time for various radioisotopes were given. Some examples of structure determination were given. (tr-auth)

**11209** VANADIUM AND NIOBIUM CARBIDES IN STEEL. A. M. Belyakov and A. A. Savinskaya. Izv. Akad. Nauk SSSR, Otd. Tekhn. Nauk, Met. i Toplivo, No. 6, 67-72 (Nov.-Dec. 1962). (In Russian)

During thermal treatment of niobium steel (1.35 to 1.50%

Nb, 0.67 to 0.70% C) at 650 to 1300°C and annealing and tempering of vanadium steel (0.97% V and 0.71% C) the content of carbon bundled, $VC_{1-x}$ and $NbC_{1-x}$, remained unchanged. (R.V.J.)

**11210** NIOBIUM AND ZIRCONIUM EFFECTS ON CAST AUSTENITIC STEEL. M. P. Braun and N. I. Matyushenko. Izv. Akad. Nauk SSSR, Otd. Tekhn. Nauk, Met. i Toplivo, No. 6, 81-9(Nov.-Dec. 1962). (In Russian)

A considerable modification of austenitic chromium–nickel steel was achieved using admixtures of 0.35 to 0.50 wt % Nb; with higher amounts (over 1% Nb) the modification was eliminated. A considerable disintegration of the dendrite structure and finer grain was observed with additions of 0.5 to 0.7% Zr. The initial structure with slightly larger grain was developed by homogenization and annealing of the Nb or Zr modified steel. (R.V.J.)

**11211** CREEP IN Ti–Sn AND Ti–Zr–Sn ALLOYS. V. V. Glazova and N. N. Kurnakov. Izv. Akad. Nauk SSSR, Otd. Tekhn. Nauk, Met. i Toplivo, No. 6, 131-6(Nov.-Dec. 1962). (In Russian)

The Ti–$Ti_3$ Sn and Zr–$Ti_3$ Sn resistance to plastic deformation was studied at various temperatures from 300 to 700°C using a hot hardness method. The obtained data indicate that admixtures of $Ti_3$ Sn reduces the rate of creep in Ti and Zr. Tables showing the rate of creep in various compositions are included. (R.V.J.)

**11212** CONSTITUTION DIAGRAM OF Ti–Nb–Cr ALLOY. K. I. Shakhova and P. B. Budberg. Izv. Akad. Nauk SSSR, Otd. Tekhn. Nauk, Met. i Toplivo, No. 6, 137-41(Nov.-Dec. 1962). (In Russian)

Phase studies were made of a Ti–Nb–Cr alloy, and isothermal cross sections were constructed at 1000, 800, and 600°C. A quasi-binominal cross section $TiCr_2$–$NbCr_2$ was observed. (R.V.J.)

**11213** STABILIZATION OF $\beta$-SOLID SOLUTION IN Zr ALLOYS. L. A. Petrova. Izv. Akad. Nauk SSSR, Otd. Tekhn. Nauk, Met. i Toplivo, No. 6, 159-61(Nov.-Dec. 1962). (In Russian)

An attempt was made to find metastable $\beta$ solid solutions by annealing Zr with V, Re, Nb, and Mo. Metallographic and x-ray diffraction analysis fixed the $\beta$ metastable state at room temperature only with 7.5 wt % Mo and 15.0 wt % Nb. (R.V.J.)

**11214** THERMODIFFUSION IN TUNGSTEN–BERYLLIUM SYSTEM. P. M. Arzhanyi, R. M. Volkova, and D. A. Prokoshkin. Izv. Akad. Nauk SSSR, Otd. Tekhn. Nauk, Met. i Toplivo, No. 6, 162-6(Nov.-Dec. 1962). (In Russian)

X-ray diffraction and spectral analyses were made of the structure and phase composition of the Be–W diffusion layer. It was shown that Be–W diffuses on the surface with parallel formation of intermetallic phases of various thicknesses. The phases are separated and their boundaries correspond to a step-line concentration curve. (R.V.J.)

**11215** PHYSICAL PROPERTIES OF METAL–CERAMIC SPECIMENS OF HfC. V. N. Paderno. Izv. Akad. Nauk SSSR, Otd. Tekhn. Nauk, Met. i Toplivo, No. 6, 176-8(Nov.-Dec. 1962). (In Russian)

Physical properties of HfC powders of 93.68% Hf with 6.3% C (bonded) and 0.02 C (free) sintered at 2900 to 3000°C and 180 kg/mm$^2$ pressure were studied. Comparisons were made with Ti and Zr carbides. (R.V.J.)

**11216** PHASE EQUILIBRIA IN THE SYSTEM NaF–$ThF_4$–$UF_4$. R. E. Thoma, Herbert Insley, G. M. Hebert, H. A. Friedman, and C. F. Weaver (Oak Ridge National Lab., Tenn.). J. Am. Ceram. Soc., 46: 37-42(Jan. 21, 1963).

Phase equilibria in the condensed system NaF–$ThF_4$–$UF_4$ were determined by cooling-curve and thermal-gradient quenching experiments from the liquidus to ~450°C. A phase diagram of the ternary system was constructed, showing three singular points and eleven invariant points, including two eutectics, occurring in association with the primary phases of ten solid solutions and two pure solids. The eutectic mixture having the composition 75.5 NaF–10.5 $ThF_4$–14 $UF_4$ (mole %) melts at 575°C, the lowest liquidus temperature in the system. Except for NaF, NaF · $ThF_4$, and $ThF_4$–$UF_4$ solid solutions, phases crystallizing from molten NaF–$ThF_4$–$UF_4$ mixtures are solid solutions formed by interchange of $U^{4+}$ and $Th^{4+}$ ions in NaF–$ThF_4$ and NaF–$UF_4$ compounds. No ternary compounds were found. Phase diagrams of the systems NaF–$ThF_4$ and NaF–$UF_4$, revised to include the newly identified phases, 7NaF · $2ThF_4$ and 7NaF · $2UF_4$, are presented. X-ray diffraction and optical data are given for the pure crystal phases, 4NaF · $ThF_4$, 7NaF · $2ThF_4$, 7NaF · $2UF_4$, 3NaF · $UF_4$, and for 3NaF · $2ThF_4$–5NaF · $3UF_4$ solid solutions. The system is unique among the fluoride systems reported in containing so wide a variety of substitutional solid solutions and in containing a continuous solid solution formed of binary compound pairs 3NaF · $2ThF_4$ and 5NaF · $3UF_4$, which are isomorphous but of different stoichiometry. (auth)

**11217** CALCULATION OF COHESIVE AND SURFACE ENERGIES OF THORIUM AND URANIUM DIOXIDES. G. C. Benson, P. I. Freeman, and E. Dempsey (National Research Council, Ottawa and Union Carbide Research Inst., Tarrytown, N. Y.). J. Am. Ceram. Soc., 46: 43-7 (Jan. 21, 1963).

The cohesive and surface energies of thorium and uranium dioxides were estimated theoretically by computations based on a Born-Mayer type of model. The sensitivity of the results to changes in the data used for the calculations is illustrated and discussed. (auth)

**11218** PROPERTIES OF RADIATION SHIELDING CONCRETE. Kazushisa Shirayama. J. Am. Concrete Inst., Proc., 60: 261-79(Feb. 1963).

A study of boron-containing aggregates from the United States and England and of seven heavy aggregates from Japan is reported. Data are presented and discussed concerning mix proportions, workability, unit weight, strength, drying shrinkage, and absorption coefficients for $\gamma$- and x-rays. Based on data obtained for mix proportions, formulas for estimating the unit weight of concrete from the specific gravity of the aggregate are proposed. The hematite ore used is found to be unsuitable for concrete aggregate because of an excessive amount of fines coating its surface. The tests indicate that, of the boron-containing material, the deleterious effects of colemanite on concrete strength and setting time is greater than that of borocalcite. This effect increases with increased fineness. The barite concretes provide better shielding against x-rays than anticipated from density calculations. Barite or magnetite concretes are more suitable in shielding against gamma rays. (auth)

**11219** MECHANICAL PROPERTIES OF NIOBIUM–OXYGEN ALLOYS. W. F. Sheely (Union Carbide Metals Co., Niagara Falls, N. Y.). J. Less-Common Metals, 4: 487-95(Dec. 1962). (In English)

Niobium with grain size ranging from 0.1 to 2 mm and with dissolved O contents ranging from 500 to 6400 ppm twins at −196°C on yielding in compression. Twinning did not occur at −196°C in samples not contaminated with O or in any of the samples at −74° or at higher temperatures.

Deliberate contamination by O seemed to promote twinning at −196°C. In the temperature range from −196 to 100°C the effect of grain size on yield strength, either with or without twinning, increased with O content. Larger grained specimens yield at lower stresses than finer grained specimens. At elevated temperatures, the greatest influence of O on tensile properties was between 300 and 400°C, where it is believed to cause strain-aging. Any effect was lost above about 700°C. (auth)

**11220** INTERMEDIATE PHASES IN BINARY SYSTEMS OF TECHNETIUM-99 WITH SEVERAL TRANSITION ELEMENTS. J. B. Darby, Jr., D. J. Lam, L. J. Norton, and J. W. Downey (Argonne National Lab., Ill.). J. Less-Common Metals, 4: 558-63(Dec. 1962). (ANL-FGF-352). (In English)

An exploratory survey was made of the intermediate phases formed when $Tc^{99}$ is alloyed with the Sc, Ti, V, Cr, Mn, and Fe-group elements. A total of nineteen intermediate phases were identified and found to be isomorphous with the $Cr_3O$-type, CsCl-type, $MgZn_2$-type, γ-phase, or σ-phase structure. The alloying characteristics of Tc are rationalized in terms of periodic table relationships. (auth)

**11221** ELECTRICAL RESISTIVITY DUE TO ELECTRON−PHONON SCATTERING IN YTTRIUM AND LUTETIUM. Sigurds Arajs and R. V. Colvin (United States Steel Corp. Research Center, Monroeville, Penna.). J. Less-Common Metals, 4: 572-8(Dec. 1962). (In English)

The intrinsic electric resistivity, $q_i(T)$, resulting from electron−phonon scattering in polycrystalline Y and Lu from 15 to 310°K was investigated. The temperature dependence of $q_i(T)$ for Y is very similar to that of Sc. Between 90 and 310°K $q_i(T)$ of Y follows the Bloch−Grüneisen equation with Debye θ of 215°K. The intrinsic electric resistivity of Lu, however, cannot be fitted to the Bloch−Grüneisen theory. The temperature dependence of $q_i(T)$ at low temperatures and the Ziman reduced resistivities at 300°K are consistent with the expectations from the interband electron−phonon scattering in Y, Sc, and Lu. (auth)

**11222** SOME APPLICATIONS OF THE INELASTIC SCATTERING OF NEUTRONS TO THE STUDY OF MAGNETIC COUPLING. B. Jacrot and D. Cribier (Centre d'Études Nucleaires, Saclay, France). J. Phys. Radium, 23: 494-6(Aug.−Sept. 1962). (In French)

Several phenomena were observed by neutron inelastic scattering: a) spin waves in magnetite and their temperature dependence; b) exchange integrals in $MnF_2$; and c) critical scattering in iron and nickel, which is shown to be nonelastic even at the Curie point. (auth)

**11223** RECENT RESULTS ON THE DEFORMATION BEHAVIOR OF THE METALS NIOBIUM, TANTALUM, MOLYBDENUM, AND TUNGSTEN AT LOW AND MODERATE TEMPERATURES. [PART] II. F. Osterman (Aeronautical Systems Div., Wright-Patterson Air Force Base, Ohio). Metall, 16: 979-84(Oct. 1962). (In German)

A review of the effect of various factors on the deformation behavior of Nb, Ta, Mo, and W is continued. The factors considered are torsional velocity, stress state, impurities, delayed flow and microcreep, tensile aging phenomena, and structure. 125 references. (J.S.R.)

**11224** METALLIC MOLYBDENUM. II. MOLYBDENUM ALLOYS. H. Braun (Climax Molybdan Gesellschaft, Zurich). Metall, 16: 990-7(Oct. 1962). (In German)

Molybdenum alloys have been used increasingly in recent years for construction materials where high thermal stability is required. Their development, especially arc melted alloys, was described, and it was shown that these alloys, because of their oxidation susceptibility, are the best available construction materials for the temperature range from 850 to 1500°C. The range of applicability of these new alloys are discussed. (tr-auth)

**11225** INVESTIGATIONS ON COPPER ZIRCONIUM ALLOYS. PART III. TESTING OF THE PROPERTIES OF THE ALLOYS WITH IMPROVED SCALING BEHAVIOR. U. Zwicker (Metallgesellschaft A. G., Frankfurt am Main). Metall, 16: 1110-13(Nov. 1962). (In German)

Investigations on the effect of the degree of purity and of oxidation inhibitors on the age hardening and conductivity have shown that an aging time of one hour at 450°C is sufficient to obtain a conductivity of over 50 Siemens units on 50% deformed samples of quenched and homogenized Cu−Zr alloys. With a deformation of more than 90% an aging of 20 to 40 min at 450°C is sufficient to obtain a conductivity of 50 SU. In alloys with Co additions longer aging times and in alloys with no addition shorter aging times were necessary for the production of this conductivity. The deterioration of the mechanical properties by increased aging is less in the Co, Be, and Nb alloys than in the pure alloys. Testing the aging behavior between 200 and 400°C shows that the Nb and Be alloys are superior to those with Co−Be additions and the addition-free alloy to the Nb and Be alloys. (tr-auth)

**11226** BeO-POROUS CERAMICS. I. Ya Guzman and D. N. Poluboyarinov. Ogneupory, No. 10, 457-62(1962).

Porosity (P), gas permeability, compressive strength, deformation under load, thermal-fatigue resistance, contraction, and heat conductivity of BeO-based lightweight porous ceramics were determined. Test specimens of varying P were prepared by mixing a suspension of pure BeO, prefired at 1400 or 1600°C and finely divided, with varying quantities of rosin-size foam, or compacting BeO-based light-weight porous material (filler), fired and crushed, with 0 to 40% petroleum coke. In the 31 to 63% P range specimens made by the first method retained some compressive strength at temperatures ≤ 1500°C, and deformation set in at ~1600°C under a load 8 times the numerical value of density in $g/cm^3$. In the 30 to 80% P range the thermal-fatigue resistance at temperatures ≤ 1000°C was >40 thermal cycles, owing to high heat conductivity. Contraction after 4 hr at 1750°C did not exceed 0.5 to 1%. Gas permeability rose and compressive strength declined with increasing P. Petroleum coke-based products were found inferior to foam-based products in mechanical properties. (P.C.H.)

**11227** A STUDY OF THE PHOTOLUMINESCENCE AND SCINTILLATION PROPERTIES OF SOME 1,3-OXAZOLE DERIVATIVES IN POLYSTYRENE. L. L. Nagornaya, V. D. Bezuglyi, and N. P. Demchenko. Opt. Spectry. (USSR) (English Transl.), 13: 288-90(Oct. 1962).

Photoluminescence and scintillation characteristics were investigated for 2-(4-biphenylyl)-5-(2-naphthyl)-oxazole-1,3; 2-(4-biphenylyl)-5-(1-naphthyl)-oxazole-1,3; and 1,2-biphenyloxazole derivatives of ethylene and ethane. It was established that the most efficient plastic scintillators are those which use 2-(4-biphenylyl)-5-(2-naphthyl)-oxazole-1,3 as the luminor. The effectiveness of scintillators of this kind is ~105% compared to a standard polystyrene calibrating block containing 2% p-terphenyl and 0.06% POPOP. (auth)

**11228** THE ROLE OF ADDITIONAL IMPURITIES IN THE FORMATION OF LUMINESCENCE CENTERS IN THE PHOSPHOR ZnS−Cu. N. A. Vlasenko and E. N. Pavlova. Opt. Spectry. (USSR) (English Transl.), 13: 308-10(Oct. 1962).

The possibility of obtaining a ZnS–Cu phosphor without coactivators was investigated. It was shown that, in this case, the absence of luminescence is related to the precipitation of copper as a colloid. A study was made of the influence of two types of additional impurities on the properties of a ZnS–Cu phosphor: impurities compensating for the excess charge produced when a $Zn^{2+}$ ion is replaced by a $Cu^{+}$ ion (such as, for example, Cl); and impurities with the same valency as the ions of the host lattice (such as Mn). It was found that both types of impurities promote the formation of green luminescence centers. A conclusion was drawn concerning the composition of the luminescence center on the basis of a comparison of the luminescence spectra of ZnS–Cu phosphors with various additional impurities. (auth)

**11229** EFFECT OF AN ELECTRIC FIELD ON THE γ-LUMINESCENCE OF ZnS SINGLE CRYSTALS. B. T. Fedyushin. Opt. Spectry. (USSR) (English Transl.), 13: 313-16(Oct. 1962).

It was found that an increase in γ-luminescence of ZnS–Mn, Cu, Cl single crystals in an electric field (assuming that the electrodes are not in direct contact with the crystal) was caused by electroluminescence induced by the external radiation. The results show clearly that the mechanism by which the electric field excites such crystals consists in the synthesis of shock ionization and tunneling. (auth)

**11230** EVIDENCE FOR ANHARMONIC BINDING OF ISOLATED Fe IMPURITY ATOMS. W. A. Steyert and P. P. Craig (Los Alamos Scientific Lab., N. Mex.). Phys. Letters, 2: 165-7(Sept. 15, 1962). (LADC-5422) (In English)

The temperature dependence of the recoil-free gamma emission probability for $Fe^{57}$ as a dilute impurity in metallic In was measured between 4 and 420°K. It is concluded that the binding forces cannot be predominately harmonic. This indicates that the properties of isolated atoms may differ markedly from these of the same type of atoms present in higher concentration. The experimental results may be qualitatively understood by considering the impurity atoms to reside in a spherical square well potential. (H.D.R.)

**11231** ELECTRICAL RESISTIVITY BY LATTICE VACANCIES IN MULTIVALENT NON-TRANSITION METALS. C. Reale (SORIN, Saluggia, Italy). Phys. Letters, 2: 268-70(Oct. 15, 1962). (In English)

Calculations of the electric resistivity increase due to impurity atoms or point lattice defects in metals have been carried out several times in the past. A new procedure is proposed to calculate the contribution to the electric resistivity by lattice vacancies in multivalent nontransition metals and to show that its application to the case of aluminum leads to the expected value for this metal. (W.D.M.)

**11232** STRUCTURE OF LIQUID MERCURY. R. F. Kruh, Glen T. Clayton, Charles Head, and Glen Sandlin (Univ. of Arkansas, Fayetteville). Phys. Rev., 129: 1479-80(Feb. 15, 1963).

Because the only available studies of the temperature dependence of liquid mercury's x-ray scattering contain false peaks in the intensity, a re-examination has been made over a 60° range (−36° to 26°) under precisely reproducible geometry. The fact that there is little variation in observed intensity and in the derived radial distribution function is consistent with the small density decrease (1%) over the range, and with the idea that scattering from hard spheres depends only upon density. The mean number of nearest neighbors is 7.5 centered at 3.03 Å. (auth)

**11233** THE TEMPERATURE DEPENDENCE OF THE CHARACTERISTIC SIZE OF THE INITIAL PART OF THE MULTI-CRYSTAL PLASTIC STRESS-STRAIN CURVE OF ALUMINIUM AND COPPER. H. Knoell and E. Macherauch (Max-Planck-Institut für Metallforschung, Stuttgart). Phys. Status Solidi, 2: K237-40(1962). (In German)

The temperature dependence of the yield point, solidification increase, and the yield stress in the temperature range from 90 to 300°K was investigated on Cu multicrystals with a mean crystallite size of 17 μ and Al multicrystals of 150 μ. The results are shown graphically and discussed. The yield point of Al increases only slightly with decreasing temperature at room temperatures, but more strongly at lower temperatures. In Cu a strongly projected temperature dependence of the yield point was observed. A temperature dependence of the plasticity in Al similiar to the yield point is observed. Cu shows a plasticity decreasing almost linearly with increase in temperature. The yield stress in both crystals is strongly temperature dependent. (J.S.R.)

**11234** MAGNETIC MEASUREMENT OF THE PLASTIC STRESS-STRAIN CURVE OF MULTICRYSTALLINE NICKEL. Ch. Schwink and G. Zankl (Universität Munich). Phys. Status Solidi, 2: K241-4(1962). (In German)

Ballistic measurements of the coercive force $H_c$ and the initial permeability $\mu_a$ were made on nickel wires, and their dependence on plastic tensile deformation was followed. The results are shown graphically. $H_c$ and $1/\mu_a$ start to increase at a given tensile stress with the introduction of plastic expansion and increases almost linearly with the tensile stress applied. At a tensile stress of $7.2 \pm 0.5$ kp/mm$^2$ both curves have noticable bends. The bend point is related by a special process to the plastic deformation of the multicrystalline material. (J.S.R.)

**11235** A SURVEY OF INTERMEDIATE PHASES IN TRANSITION-METAL ALLOYS. Y. L. Yao (Department of Mines and Technical Surveys, Ottawa). Trans. AIME, 224: 1146-53(Dec. 1962).

It is suggested that the binary alloy systems of transition metals may be classified into groups according to excess energy, ΔE. For systems with positive ΔE, the Laves phase, the $TiNi_3$-, the $TiCu_3$- and the $Cu_3Au$-type rich in the smaller atom and the $Ti_2Ni$-type rich in the larger atom may exist. For systems with negative ΔE and composed of two components of different crystal structures, the χ, the $Cr_3O$ and the σ phase may exist on the side of the phase diagram rich in the component with the higher solubility factor value and the $Cu_3Au$-type and the disordered hcp phase on the other side; if the crystal structure of two components is the same, the $Cu_3Au$-type may exist on both sides. For systems with weakly positive ΔE and composed of different crystal structures, the μ phase and the $MgCd_3$-type may replace the Laves phase and the other types; the χ, the $Cr_3O$, and the σ phase may also exist. Finally, the equimolar compounds of the CuAu- and the CsCl-type may exist irrespective of the sign of ΔE. (auth)

**11236** A METHOD FOR SEPARATING GRAIN-BOUNDARY AND LATTICE DIFFUSION EFFECTS IN POLYCRYSTALLINE MATERIALS. T. S. Lundy and J. I. Federer (Oak Ridge National Lab., Tenn.). Trans. AIME, 224: 1285(Dec. 1962).

A graphical method was developed and tested for separating the effects of grain boundary and lattice diffusion in polycrystalline materials. The method is based on the assumptions that for unidirectional diffusion from a plane source of radioactive material, the penetration of activity

far into the specimen from the source is due solely to grain-boundary effects, and pure grain-boundary penetration is described by a linear plot of log activity vs the perpendicular distance x from the source. The separation of grain-boundary effects from lattice effects for $Nb^{95}$ diffusion in pressed and sintered $UO_2$ is plotted as an example. (P.C.H.)

**11237** CRYSTAL STRUCTURE OF SATURATED MIXED HYDRIDES OF TITANIUM AND NIOBIUM (COLUMBIUM). G. S. Upadhyaya and A. D. McQuillan (Univ. of Birmingham, Eng.). Trans. AIME, 224: 1290-1(Dec. 1962).

The total amount of hydrogen absorbed by mixed hydrides of Nb and Ti and the room temperature crystal structure of the hydride powders were determined. An x-ray investigation indicated that the fcc hydride phase arises from alloys extending in composition from Ti to 67 at. % Nb. After a two-phase field lying between 67 and 74 at. % Nb in which the fcc and bcc hydrides coexist, alloys richer in Nb yield a distorted bcc hydride. Over the whole range of the fcc hydride phase the hydrogen content remains constant, while in the distorted body-centered hydride phase, the hydrogen content increases with increasing Ti content reaching a hydrogen/metal ratio of 1.4 at the boundary of the two-phase region. It seems likely that the maximum hydrogen content is controlled entirely by factors of crystal geometry and that the solubility of hydrogen in Nb-rich alloys with either Ti or Mo is controlled by an electronic factor. (P.C.H.)

**11238** ANOMALIES IN THERMAL EXPANSION OF DILUTE SOLID SOLUTIONS. K. S. Krishnan and A. G. Guy (Univ. of Florida, Gainesville). Trans. AIME, 224: 1291-2(Dec. 1962).

Measurements were made on the coefficient of thermal expansion in dilute Fe–W and Fe–Mo alloys and the results are shown graphically. It was tentatively concluded that no major anomaly in thermal expansion exists at low concentrations of W and Mo in Fe. (P.C.H.)

**11239** MARTENSITE TRANSFORMATIONS IN ZIRCONIUM, TITANIUM, AND TITANIUM–COPPER ALLOYS. L. P. Srivastava and J. Gordon Parr (Univ. of Alberta, Edmonton). Trans. AIME, 224: 1295-7(Dec. 1962).

Titanium, Zr, and Ti–Cu alloys were prepared by levitation melting under Ar in the compositions 0.5, 1.0, 1.5, 3.0, 5.2, and 8 at. %. The criterion of martensite formation was the effect of surface rumpling. Previously polished samples that showed a rumpled surface after transformation were assumed to have undergone martensitic transformation; transformations of a diffusion type produce no surface disturbance. For all metals and alloys a gradual depression of transformation temperature with increasing cooling rate was recorded, to the critical cooling rate. At and above this rate, the transformation temperature was constant. An 8% Cu alloy showed no signs of martensitic transformation. Twins were observed in polished and martensitically transformed Ti and Ti–Cu samples. (P.C.H.)

**11240** THE SOLID SOLUBILITY OF ZIRCONIUM IN COPPER. Walter Showak (Ford Motor Co., Dearborn, Mich.). Trans. AIME, 224: 1297-8(Dec. 1962).

An investigation was made of the Cu–Zr system for the purpose of accurately establishing the solidus and solvus curves and the eutectic temperature in Cu-rich alloys. Metallographic and electric resistivity measurements were used as the primary methods for the investigation, although some thermal analysis studies were also performed. From breaks in the electric resistivity vs concentration curves for the alloys, the limits of Zr solubility in Cu at the various temperatures were ascertained. The maximum solubility of Zr in Cu was found to be 0.24 wt. %. The apparent molar heat of solution of Zr in Cu was calculated to be 28900 cal per mole. (P.C.H.)

**11241** LIQUID BISMUTH PENETRATION INTO BOUNDARIES IN ORIENTED BICRYSTALS OF NICKEL. G. H. Bishop, B. F. Addis, C. A. Steidel, and C. W. Spencer (Cornell Univ., Ithaca, N. Y.). Trans. AIME, 224: 1299-1300(Dec. 1962).

Studies were made on the penetration of Bi-rich Ni–Bi liquids into oriented bicrystal specimens of Ni. It was found that isothermal penetration follows a parabolic rate law, $x = (kt)^{1/2}$, and that the penetration is anisotropic with respect to direction $k_\perp/k_\parallel$ being 1.7, where $k_\perp$ and $k_\parallel$ denote the rate constant, perpendicular and parallel to common (100), respectively. (P.C.H.)

**11242** WELDING COLUMBIUM AND COLUMBIUM ALLOYS. W. N. Platte (Westinghouse Research Labs., Pittsburgh). Welding J. (N. Y.), 42: 69s-83s(Feb. 1963).

The development of a welding technique for pure Nb and the design and development of weldable Nb alloys are described. To avoid changes in properties, welding was done in a closed chamber using an atmosphere of He, since N can be removed more easily from He than from Ar. The properties of welds made under pure He atmospheres were compared with those of welds made under atmospheres contaminated with $N_2$ and $O_2$. Alloys were designed using weldability parameters based on the physical, mechanical, and the metallurgical properties of Nb and its possible alloying elements. The design parameters were used to screen out alloy additions that would produce hot cracking, porosity, loss of ductility at ambient temperature, and other welding defects. Alloys containing Ti, Mo, W, V, Hf, Zr, and U were selected as being weldable, and these alloys, with the exception of the Nb–U alloy, were made, welded, and tested. The selected alloys were found to be weldable. The hardness and microstructures of the alloys were studied and the data are included. A weld in an alloy of Nb and W was tested in tension at 1000 and 1093°C (1832 and 2000°F) and found to have strengths comparable to the base material. (P.C.H.)

**11243** WELDING CHARACTERISTICS OF COMMERCIAL COLUMBIUM ALLOYS. J. M. Gerken and J. M. Faulkner (Thompson Ramo Wooldridge Inc., Cleveland). Welding J. (N. Y.), 42: 84s-96s(Feb. 1963).

The welding characteristics of three commercial Nb-base alloys (FS82, D31, and F48) were investigated. Both gas tungsten-arc and electron beam welding were included. Welds were evaluated for bend ductility transition temperature, hardness, tensile strength, and microstructure. The effects of travel speed, shielding gas composition and purity, filler metal additions, preheat, and postheat were investigated. Gas tungsten-arc welding was performed in a vacuum purge atmosphere chamber; however, for comparison, some welds were made without the use of a chamber but with careful back shielding and trailer shielding. Thermal cycles were measured in the fusion and heat-affected zones of gas tungsten-arc welds to help explain mechanical properties and microstructure on the basis of physical metallurgy of each alloy. The most significant effect of welding on all alloys investigated was the lowering of ductility or increasing the ductile to brittle transition temperature. Postweld aging studies were conducted on FS82 alloy welds to determine the effect on ductility. Electron micrographs of the heat-affected zone and fusion zone

indicate that the loss of ductility is caused by an aging reaction and that ductility is regained as overaging takes place. Electron beam welds in D31 and F48 were significantly more ductile than gas tungsten-arc welds in these alloys. It is believed that ductility is lowered in welds in these materials by solution of an embrittling phase followed by precipitation during the weld thermal cycle. The smaller loss in ductility associated with electron beam welding may be the result of two factors—a higher purity weld puddle provided by the vacuum environment and a much shorter time the weld was at elevated temperature. (P.C.H.)

**11244** THE ADSORPTION OF $Pm^{147}$ ON METAL SURFACES. Lennart Junghahn. Werkstoffe Korrosion, 13: 474-9(Aug. 1962). (In German)

Promethium-147 was used to study complicated surface processes on metals. Its exact physical and chemical behavior, especially when adsorption takes place, were studied by means of a series of tests carried out with a diluted $PmCl_3$ solution on the surfaces of Au, Ta, Ti, and stainless steel. The adsorption rate was measured by means of $\beta$-counters and autoradiography. Results indicated that $Pm^{147}$ exists as a radiocolloid in the pH range of $6 \sim 7$, and the adsorbed amount is linearly proportional to the solution concentration within a narrow range. In contrast to adsorption, the desorption of $Pm^{147}$ is a very slow process. (OID)

**11245** THE SCATTERING OF THE FATIGUE TEST VALUES OF LIGHT METAL ALLOYS. Karl Ernst Mann. Z. Metallk., 53: 645-52(Oct. 1962). (In German)

The scatter in results of fatigue tests is of statistical nature, and conforms sufficiently accurately to logarithmic normal distribution. The influence of structural factors on the scatter is insignificant. When using ductile materials, a disadvantageous influence of inclusions, e.g., caused by internal notch effects, cannot be established. Inclusions consisting of insoluble intermetallic compounds are disadvantageous only if the original material, e.g., by exploitation of the "Pre $\beta$-effekt" for obtaining utmost static and dynamic strength properties, is hardened to the limit of its workability. The endurance bending strength of the ductile Al–3% Mg was determined accurately to ±2%. With increasing tensile strength and yield strength, or decreasing elongation, the scatter increases continuously, although for light alloys with maximum strength it is not essentially more than 10%. (auth)

**11246** THE EFFECT OF COLD WORKING ON THE SINGLE PHASE SEGREGATION OF ALUMINUM–ZINC AND ALUMINUM–COPPER ALLOYS. Gunnar Bartsch and Siegfried Bogott (Universität, Berlin). Z. Metallk., 53: 653-60(Oct. 1962). (In German)

By means of resistivity and hardness measurements, the influence of the deformation by cold-drawing and rolling on the kinetics of hardening of binary alloys of aluminium with 15% zinc or 4% copper was investigated. It is concluded that the material hardens after deformation in a fast reaction, probably caused by the migration of vacancies produced during the deformation. As the vacancy-density decreases in a short time because of the density of sinks for vacancies in deformed material, the fast reaction stops rapidly. Further hardening proceeds in a slow reaction for which an energy of activation of 19.7 kcal/mol is measured. After annealing and quenching deformed material from temperatures where reversion but no recrystallization takes place, only hardening of the slow reaction type is observed. The normal hardening kinetics after quenching due to the migration of "frozen-in" vacancies is observed in deformed material only after annealing above the recrystallization temperature. (auth)

**11247** THE HIGH-DUCTILE STATE OF ALLOYS ON AN ALUMINUM–ZINC BASIS. [PART] III. Werner Schulze and Franz Sauerwald (Martin-Luther-Universität, Halle-Wittenberg, Ger.). Z. Metallk., 53: 660-9(Oct. 1962). (In German)

The results of numerous measurements on an aluminium alloy containing 79 wt % Zn in the highly ductile and the normal ductile state are communicated. The possible reasons for the highly ductile behavior are discussed. (auth)

**11248** INVESTIGATIONS ON THE PHASE TRANSFORMATION IN THE ALLOY Ti–16% V–3% Al. Ulrich Zwicker (Metallgesellschaft A. G., Frankfurt am Main). Z. Metallk., 53: 675-87(Oct. 1962). (In German)

Caloric measurements on $\beta$-quenched martensitic and martensite-free samples of the alloy Ti–16% V–3% Al showed the same kinetics of transformation, though the transformation of the martensitic samples leads to a different intermediate phase than is found in martensite-free samples. After the formation of the prestage of the $\omega$-phase and after the formation of the $\omega$-phase itself a caloric effect is found, which seems to be due to the reversion of these two intermediate phases. The formation of the prestage is supposed to be a short-range ordering process. It is connected with an increase of hardness and electrical conductivity. The transformation curves in the TTT-diagram are shifted to longer times by additions of aluminium and hydrogen and to shorter times by cold work. (auth)

**11249** DETERMINATION OF THE COMPOSITION OF THE TERNARY X PHASE IN THE THREE-COMPONENT SYSTEM ALUMINUM–MANGANESE–NICKEL BY UTILIZATION OF A NEW METHOD FOR THE EVALUATION OF THE TEST RESULTS. J. W. H. Clare and G. E. G. Tucker. Z. Metallk., 53: 688-91(Oct. 1962). (In German)

Analysis of crystals of the X phase extracted from aluminium-manganese-nickel alloys has shown the composition to be variable owing to the existence of a homogeneity range. Novel applications of mathematical statistics and the theory of numbers were used to detect inconsistent results and to rationalize the selection of the empirical formula of the phase. The formula found was $Ni_3Mn_{13}Al_{62}$. The present work indicates that considerably less nickel is present in this phase than was previously believed and reasons are given which might account for this difference. The density of the phase was found to be 3.61 p/cm$^3$ and the hardness 523 kp/mm$^2$. (auth)

**11250** PIEZOELECTRIC PULSE MEASUREMENTS DURING THE MECHANICAL STRESS OF Al–3% Mg AND 99% Al. Heinz Borchers and Hans Maria Tensi (Technische Hochschule, Munich). Z. Metallk., 53: 692-5(Oct. 1962). (In German)

The piezoelectric measurement of mechanical impulses that appear during plastic deformation of samples consisting of Al–3% Mg and Al (99% pulses) is reported. By means of different heat treatment the formation of the yield strength and the delivery of impulses can be varied. The connection between mechanical impulses and the energy of deformation is discussed using macroscopic atomic theories. (auth)

**11251** SUPERCONDUCTIVITY OF LANTHANUM FOILS AND OF VAPOR DEPOSITED LANTHANUM FILMS WITH ADDITION OF GADOLINIUM. Klaus Schwidtal (Universität, Göttingen, Ger.). Z. Physik, 169: 564-75(1962). (In German)

Foils of lanthanum were found to be converted entirely to the hcp modification by the rolling process. This made it

possible to obtain the superconducting transition temperatures for both the hcp and fcc modifications of lanthanum from measurements of the electrical resistivity. Lanthanum foils in the hcp form exhibited a superconducting transition at 4.9°K, while foils in the fcc form became superconducting at 6.0°K. Cold working lowered the transition temperature of the hcp modification. Quenching condensation provided films of the hcp modification, their transition temperature being depressed by the quenching condensation. Small additions of gadolinium lowered the transition temperatures as well of the quenchingly condensed as of the annealed films at the same rate of 4.5°K per at % Gd. From the accordance of these rates it is concluded that the lowering of the transition temperature by paramagnetic impurities is not affected by quenching condensation. The results of the measurements on La-Gd films are also in accord with those of Matthias et al. obtained on bulk specimens. (auth)

**11252** CHANGE IN THE THERMODYNAMIC POTENTIAL OF ION EXCHANGE RESINS DURING ION EXCHANGE. G. V. Samsonov and V. A. Pasechnik (Inst. of High Molecular Compounds, Academy of Sciences, Leningrad). Zh. Fiz. Khim., 36: 2727-33(Dec. 1962). (In Russian)

Relations in ion exchange and the effect of swelling were experimentally investigated on SBS resins for the system terramycin hydrogen and tetraethylammonium–sodium. The free energy of swelling was regarded as a function of the sorbent composition. An analysis of the results showed the existence of a correlation between the free energy of swelling and the total change in free energy of the exchange process. The absence of parallel change of the functions can be explained by the appearance of additional interaction between the sorbed ion and the polymer chains on increase in the degree of crosslinkage of the sorbents. (P.C.H.)

## Radiation Effects

*Refer also to abstract 11952.*

**11253** (BLG-140) MODIFICATION DES CARACTERISTIQUES RADIOACTIVES DES ISOTOPES DE L'URANIUM AU COURS DE L'IRRADIATION. CONSEQUENCES POUR LES CONDITIONS DE RETRAITEMENT ET DE REFABRICATION. (Modifications of the Radioactive Characteristics of Uranium Isotopes in the Course of Irradiation. Consequences for Reprocessing and Refabrication Conditions). J. Schmets and J. Broothaerts (Brussels. Centre d'Etude de l'Énergie Nucleaire). Sept. 1962. 20p.

Uranium $\alpha$ and $\gamma$ activity increases appreciably with $U^{235}$ enrichment; this is due almost entirely to the 234 isotope. Irradiation does not appreciably affect the U $\alpha$ activity; however, the $U^{234}$ concentration could become relatively high if the fuel is recycled. After reprocessing, the natural isotopes of U, separated from their daughter and fission products, have a low $\beta$–$\gamma$ activity which will grow again at a rate which is faster for more highly enriched material. Irradiation causes the formation of $U^{236}$, source of $U^{237}$; the activity of the latter determines the cooling time of the fuel. The $\alpha$, $\beta$, and $\gamma$ activities and their variation are discussed as a basis for defining some reprocessing and refabrication conditions. Their effect on purity norms for U and on cycle economics was especially considered. (auth)

**11254** (BMI-1608) HIGH-TEMPERATURE IRRADIATION TEST OF $UO_2$ CERMET FUELS. Donald L. Keller, George W. Cunningham, William E. Murr, Earle O. Fromm, and Donald E. Lozier (Battelle Memorial Inst., Columbus, Ohio). Jan. 7, 1963. Contract W-7405-eng-92. 22p.

Niobium-clad niobium cermets and Type 430 stainless steel-clad molybdenum and chromium cermets, all containing 80 vol % 20% enriched $UO_2$, prepared by vapor-deposition techniques or from the powders and densified and clad by gas-pressure bonding, were subjected to high-temperature high-heat-flux irradiation in the MTR. Two instrumented double-walled capsules, each containing duplicate NaK-immersed cylindrical specimens of the three compositions were involved. Specimen diameters were varied according to the particular cermet thermal conductivity in an attempt to secure central temperatures of about 0.6 of the matrix melting point. Probably because of weld failures in both capsules, irradiation temperatures were higher than intended, causing loss of the chromium cermets in one capsule and all of the cermets in the other capsule. The remaining specimens were given a post-irradiation dimensional and metallographic examination. The niobium-clad niobium-$UO_2$ cermet exhibited excellent stability at estimated center-line temperatures above 2500°F. A density decrease of only 1.4% was measured at a burnup of about 4 at.%. Although the capsule overheating caused the molybdenum-$UO_2$ cermet to partially melt, areas only a few mils from the melted zone showed no evidence of damage from the adverse conditions of the irradiation. (auth)

**11255** (BNL-6083) RADIATION DAMAGE IN GRAPHITE. I. THE ACTIVATION ENERGY FOR ANNEALING SINGLE INTERSTITIALS IN NEUTRON IRRADIATED GRAPHITE AND THE ABSOLUTE RATE OF FORMATION OF DISPLACED ATOMS. Donald G. Schweitzer (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT(30-2)-Gen-16]. 22p.

The activation energy for the process of annealing single interstitials in neutron irradiated graphite and the absolute rate of formation of displaced atoms have been determined experimentally from both the dimensional expansions and C-axis expansions of graphite irradiated at temperatures between 77 and 490°K. The activation energy obtained is 0.068 to 0.074 ev and lies between the value of 0.1 ev estimated by Dienes and the value of 0.016 ev calculated by Iwata et al. for the migration energy of a single interstitial. The absolute rate of formation of displaced atoms corresponds to the rate of displacement when no annealing occurs during the irradiation process. The value obtained ($5 \times 10^{-3}$% displaced atoms/Mwd), is 2.5 times the rate of displacement at 30°C and agrees well with theoretical estimates. The dimensional changes occurring during the first irradiation of graphite are the result of the three processes: (1) $\phi + C^0 \rightarrow C_1$ + vacancy, (2) $C_1 + C_1 \rightarrow C_2$, and (3) $C_1$ + Trap $\rightarrow C_1$ T. Reaction (1) corresponds to the displacement of a single interstitial by collision of a fast (high energy) neutron and the graphite lattice. This reaction is temperature independent. Reaction (2) represents the collision of two interstitials to form a stable $C_2$ complex. The dimensional changes (rate of growth) occurring in graphite are due to the constant (zero order) rate of formation of $C_2$. Some of the single interstitials anneal (without causing dimensional changes) by being trapped at pores, edge atoms, etc. Reaction (3) describes this process. The rate determining step for both reaction (2) and reaction (3) is the rate of migration of the single interstitial. (auth)

**11256** (CRFD-1119) THE IRRADIATION OF HYDRAULIC RABBIT SPECIMENS TO STUDY SHEATH DE-

FORMATIONS. M. J. F. Notley and W. D. C. Fitzsimmons (Atomic Energy of Canada Ltd., Chalk River, Ont.). Dec. 1962. 18p. (AECL-1664)

Specimens of $UO_2$ sheathed in 0.51 mm aluminum or 0.25 mm or 0.66 mm stainless steel were irradiated in the Hydraulic Rabbit of NRX to study sheath deformations. Axial expansions were in accordance with a model in which the $UO_2$ is assumed to have a plastic core, sheath expansion being caused by expansion of the innermost non-plastic ring of $UO_2$. It was shown that the weaker the sheath the greater is the axial expansion. Diametral expansions increased with increasing specimen heat rating, increasing rapidly at ratings corresponding to the onset of central melting. Volume expansions of the Hydraulic Rabbit specimens were approximately the same as volume expansions of elements irradiated in pressurized water loops. (auth)

**11257** (EURAEC-464) SWELLING OF URANIUM. Quarterly Report No. 8, July 1–September 30, 1962. (Mol, Belgium. Centre d'Etude de l'Energie Nucléaire). Work Performed under United States–Euratom Joint Research and Development Program. Contract 022-60-09RDB I.2.5. 31p. (R-2179)

Preliminary results of an electron transmission study of high-purity thin $\alpha$–U foils are presented. The method of preparing U foils of about 20 $\mu$ thickness for study of dislocations and radiation damage is described. Some foils were deformed by cold work and then partially annealed at 550 to 650°C; others were irradiated in the BRI reactor to a dose of $10^{17}$ n/cm$^2$. In order to obtain specimens transparent to electrons the foils were finally thinned by electropolishing. The dissociation of dislocations into partials in $\alpha$–U was observed. These observations are discussed by means of a theoretical consideration of the structure of $\alpha$–U. It is pointed out that dissociation into partials is geometrically possible for dislocations in the c-plane. Numerous twins were also observed in the foils. The tips of the twins are sometimes fragmented and many dislocations are emitted from the non-coherent twin boundaries on the tips, thus enhancing the dislocation density within the grains. Features are also observed which are assumed to be stacking faults. Specimens irradiated at 80°C to a dose of $10^{17}$ n/cm$^2$ show considerable damage in form of defect clusters. The defect clusters are lined up in one or occasionally two preferential directions within the grains. This observation points to an important role of the crystal structure in damage formation in $\alpha$–U. Movement of defect clusters could also be observed directly, although the exact nature could not yet be established. Some twins show zones denuded of clusters on each side of the twin. (auth)

**11258** (HW-69945) THERMAL CONDUCTIVITY OF $UO_2$. J. L. Daniel (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.); J. Matolich, Jr., and H. W. Deem (Battelle Memorial Inst., Columbus, Ohio). Sept. 1962. Contract AT(45-1)-1350. 39p.

Thermal conductivity was measured on several types of $UO_2$ specimens, both irradiated and nonirradiated. Variations in fabrication conditions can result in wide differences in thermal conductivity. High density, nonsintered, crystal compacts have a low, nearly temperature-independent conductivity while sintered polycrystalline $UO_2$ exhibits typical decreasing conductivity inversely proportional to temperature. Single crystals of $UO_2$ display increasing heat transfer rates at temperatures above 700°C, probably as a result of contributions by radiation and other energy transfer mechanisms. Irradiation of sintered $UO_2$ at less than 100°C causes a decrease in thermal conductivity to 50% or less of its nonirradiated value near room temperature. As the temperature is raised, conductivity tends toward the corresponding nonirradiated values; pronounced stages of "recovery" occur near 150 and 400°C, and less definitely near 800°C. This thermal annealing coincides with $UO_2$ crystal lattice parameter recovery, and appears to be associated with crystal lattice damage sustained during irradiation. Above 1000°C, no significant influence of irradiation on sintered polycrystalline $UO_2$ was observed. (auth)

**11259** (HW-71521(Rev.)) MEASUREMENT OF CYLINDRICAL SHAPES. K. R. Merckx and R. G. Wheeler (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Aug. 27, 1962. Contract AT(45-1)-1350. 23p.

The measurement of a cylinder or tube and the significance of these measurements as related to fuel element fabrication and/or irradiation performance is described. Instead of the previous use of isolated measurements, continuous records of radial displacements and tube wall thickness are used to evaluate mean diameters, warp, ovality, mean wall thickness, and eccentricity. Description of the measuring and data recording equipment and the method of harmonic analysis with its interpretation and computer program are given. An evaluation is made of the experience obtained on fuel tubes measured before irradiation. The data developed from this preirradiation study and the matching postirradiation study are an integral part of fuel element testing and metallurgical evaluation program. (auth)

**11260** (HW-SA-2650) EVOLUTION OF URANIUM DIOXIDE STRUCTURE DURING IRRADIATION OF FUEL RODS. D. R. de Halas and G. R. Horn (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). June 25, 1962. Contract AT(45-1)-1350. 36p.

The characteristic microstructure of $UO_2$ observed in irradiated fuel rods is interpreted as resulting from a particular sequence of events. These are: initial melting of the central region; rapid columnar grain formation adjacent to the molten region; subsequent solidification of the core; and upon long exposure, slow continued columnar grain formation. Quantitative analyses of four irradiation test capsules reveal that the observed structure is consistent with this hypothesis. (auth)

**11261** (LAMS-2814) REACTOR IRRADIATION OF URANIUM-IMPREGNATED GRAPHITE AT 1500°C TO 10% BURNUP. P. J. Peterson, J. A. Leary, and W. J. Maraman (Los Alamos Scientific Lab., N. Mex.). Dec. 1962. Contract W-7405-eng-36. 42p.

Two type-AUC graphite fuel elements loaded by solution impregnation to an average concentration of 0.115 g/cc of 93.13% enriched U converted to UC and $UC_2$ were irradiated at temperatures of about 1500°C to a 10.2% maximum burnup, corresponding to an irradiation level of 219 kwh/cc or $2.45 \times 10^{19}$ fissions/cc of fuel element. Post-irradiation measurements of the elements showed dimensional changes of −4.3 and −4.8% with the grain, and −0.8 to −2.5% across the grain. Weight losses were 3.2 and 5.1% for the individual elements with approximately 11% of the total $U^{235}$ being lost from the elements. With-the-grain thermal conductivity at nominal room temperature was reduced by a factor of ~7 and electrical conductivities by factors of 3.4 to 6.3, also at room temperature. Impact strength appeared to be somewhat improved by irradiation. Migration of U within the element was detected by radiographic density observations but not evaluated quantita-

tively. As anticipated, fission product release was high. (auth)

**11262** (NARF-62-15T) ENERGY STORAGE MECHANISMS IN LIQUID HYDROGEN. H. G. Carter (General Dynamics/Fort Worth. Div. of General Dynamics Corp., Fort Worth, Tex.). Oct. 31, 1962. Contract AF33(657)-7201. 132p. (FZK-9-180)

Section II, Task 1, Item 5 of FZM-2386.

Energy-storing molecular products of radiation in liquid $H_2$ are examined from the point of view that the expulsion of potential energy in the form of such products may lead to lower design weights for nuclear rockets. It is found that a significant fraction of the energy deposited by radiation in liquid $H_2$ is stored temporarily through the dissociation and excitation of $H_2$ molecules. Experimental and theoretical results are consistent with a rate of dissipation of such energy into thermal motion which is much slower than the rate at which the radiation products are expelled from the tank. It is shown that, if this is the case, relatively high levels of infrared radiation are to be expected but that such energy will not rapidly be translated into thermal motion. It is concluded that, insofar as radiation heating of the propellant is a significant design factor, further consideration should be given to radiation-induced reactions in liquid $H_2$ and that any radiation-heating experiments should be interpreted in terms of possible energy-storage effects. (auth)

**11263** (NP-12361) RADIATION EFFECTS ON SOLAR CELLS (thesis). James Warren Diebold (Air Force Inst. of Tech., Wright-Patterson AFB, Ohio). May 1962. 63p. (GNE/Phys/62-6)

Gallium arsenide and Si solar cells were irradiated with protons and deuterons at 195 to 2 Mev. The electrical characteristics of the solar cells were measured before and after irradiation using a space solar simulator. The space solar simulator provides a light source similar to the sun and a space environment for testing solar cells. Measurements were also made during irradiation using floodlamps as a light source. The results indicate that deuterons are more damaging than protons by a factor of 3 to 5, and gallium arsenide cells are more resistant to radiation than Si solar cells. (auth)

**11264** (NP-12388) EFFECTS OF NUCLEAR RADIATION IN A LIQUID HYDROGEN MEDIUM. COLLECTION BETWEEN PARALLEL PLATES OF IONIZATION PRODUCED BY NUCLEAR RADIATION IN CRYOGENIC MEDIA. Quarterly Report No. 1, December 27, 1960–March 31, 1961. Alexander Thomas (Tracerlab, Inc., Waltham, Mass.). Contract NASR-20. 15p.

The recombination of $\alpha$ and $\beta$ particles in a cryogenic media between two plates is investigated. In a liquid, much of the ionization that would be formed if the medium were gaseous is instantly recombined because of the short range of the $\alpha$ or $\beta$ particles and the inability of ionization to separate sufficiently through the influence of thermodynamic processes and the electric field present. The columnar and the preferential recombination of ions in a liquid are investigated by comparing the effects of $\alpha$ and $\beta$ excited ionization in liquid $N_2$ and $H_2$. $Po^{210}$ was used as the $\alpha$ emitter and $Kr^{85}$ was used as the $\beta$ emitter. In the case of cryogenic liquids the recombination coefficient $\alpha$ is defined as $(dn/dt) = \alpha n^2$ where n is the concentration of plus and minus ions and t is time before recombination. Measurements of ion currents in liquid $N_2$ revealed that the ion current decreased with time and that the readings became increasingly erratic. The cause of this decrease may be the result of formation of ice insulation on the plates caused by air condensation. Also, the ionization in the region close to the source tends to short circuit the field thus reducing the ion current. No theory for nonuniform ionization of the collecting volume was developed. However, it is shown that a plot of ion current vs electrostatic field is nonlinear for large plate separation and linear for small plate separation. (J.R.D.)

**11265** (TID-15774) SWELLING OF URANIUM. B. A. Loomis (Argonne National Lab., Ill.). Mar. 26, 1962. Contract [W-31-109-eng-38]. 18p. (UAC-6254)

Pure U specimens were irradiated to ~0.3 at. % burnup at 275°C and then annealed at various temperatures in order to study the mechanism of swelling. For annealing at temperatures below 550°C, the density decreased by less than 1%. At temperatures above 550°C up to the $\alpha$-$\beta$ transformation temperature, the swelling increased sharply with temperature. A sharp increase in swelling was observed at ~600°C, probably due to bubble formation in recrystallized areas. (D.L.C.)

**11266** (TID-15896) GAMMA-RAY INDUCED EXPANSION OF LITHIUM FLUORIDE. William Primak and Gene Wolfe (Argonne National Lab., Ill.). Apr. 1962. Contract [W-31-109-eng-38]. 16p. (UAC-6342)

The specimens were irradiated at several different temperatures, and measurements were made of the expansion and the F- and 450-absorption bands at room temperature. Results indicate that the oscillator strength of the 450-center is about $^1/_4$. There is evidence that some of the generated vacancies are stabilized in other ways. These additional vacancies can vary for other samples and/or conditions. (J.R.D.)

**11267** (TID-15959) RADIATION DAMAGE TO SEMICONDUCTOR DEVICES. J. W. Easley (Sandia Corp., Albuquerque, N. Mex.). [May 1962]. Contract [AT(29-9)-789]. 43p. (SCDC-2668)

Three classes of radiation effects on semiconductor devices are considered: displacement effects, surface effects, and ionization effects. Discussions, tables, and graphs are included. (M.C.G.)

**11268** (TID-16999) RADIATION STABILITY OF ORGANIC FLUIDS. California Research–AEC Report No. 17. Progress Report, April 1 to June 30, 1962. R. O. Bolt, M. L. Burrous, J. G. Carroll, K. L. Hall, M. A. Sweeney, and W. W. West (California Research Corp., Richmond). Sept. 21, 1962. Contract AT(04-3)-248. 40p.

Preliminary results from the Susie program confirm that there is a fast neutron effect in polyphenyls. Furthermore, radiation stability depends on temperature and on high boiler content. Qualitatively, G-M (molecules destroyed 100 ev absorbed) is higher for neutron-rich than for gamma-rich irradiations. G-M is lower for higher conversion and increases with higher irradiation temperature. Results of extensive radiation monitoring in the neutron-rich facility indicate that the Susie neutron spectrum is very close to a Cranberg (fission) spectrum for energies greater than 1 Mev. Thus, the Cranberg spectrum is a good approximation for calculating the energy absorption integral. In this facility, about 95% of the energy absorbed is from the slowing down of fast neutrons. Organic coolants were irradiated in the Susie reactor; all irradiations and radiation monitoring operations are complete. Analyses of data from irradiated samples and other data will continue. (auth)

**11269** (VDIT-16(2.4)) RADIATION EFFECTS ON SOLID, URANIUM BASED NUCLEAR FUEL MATERIALS. Vol. 2, No. 4. A Bibliography. W. Uhlmann (Aktiebolaget Atomenergi, Stockholm). Dec. 1962. 33p.

Fifty abstracts are presented, arranged into the follow-

ing sections: general, metallic uranium, alloys, ceramic oxides, carbides and other refractory compounds, and dispersion fuels. Indexes are provided. (D.L.C.)

**11270** (WAPD-T-1455) EFFECTS OF HIGH BURNUP ON OXIDE CERAMIC FUELS. M. L. Bleiberg, R. M. Berman, and B. Lustman (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). Mar. 1962. Contract AT(11-1)-Gen-14. 142p.

The results of irradiation tests to high fission depletions on fuel element samples containing $UO_2$, $ZrO_2 + UO_2$ solid solutions, and $UO_2$ dispersed in matrices of BeO and $Al_2O_3$ are compared. The irradiation-induced volume changes are shown to result from identical swelling rates of $UO_2$, $ZrO_2 + UO_2$, and BeO but with variation in the fission fragment induced plasticity of these materials in-pile. The relative magnitude of these in-pile creep rates is related to their crystal lattice symmetry. The swelling behavior of $Al_2O_3$ at low temperatures is masked by an intervening, low temperature phenomenon causing excessive swelling at low exposure. These materials all exhibit similar fission gas retentive abilities and the fractional gas release may be related to volume diffusion theory. Irradiation-induced phase changes were observed in the $ZrO_2$-base fuel materials, with multi-phase compositions homogenizing into a single, metastable phase of the cubic fluorite-type structure. Evidence for fission product segregation, precipitation of volatile and non-volatile fission products, and oxidation of Zircaloy cladding by fission-released oxygen is noted. (auth)

**11271** (EURAEC-410) BASIC STUDY OF THE IN-PILE BEHAVIOR OF PLUTONIFEROUS MATERIALS. Quarterly Report No. 3, April 1 to June 30, 1962. (Société Belge pour l'Industrie Nucléaire, Brussels and Brussels. Centre d'Etude de l'Energie Nucléaire). July 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 078-61-12RDB. 22p. A translation of BN-6207-03.

The effective thermal conductivity of $UO_2$ at 2800°C was determined, and the activation energy of the $UO_2$ grains used in the tests was estimated to be 38 kcal/mole. Other effort was devoted to development of apparatus needed for fuel element pre- and post-irradiation tests. (J.R.D.)

**11272** NUCLEAR PARTICLE TRACKS IN SILICON. D. P. Miller and H. L. Taylor (Texas Instruments, Inc., Dallas). Appl. Phys. Letters, 2: 33-4(Jan. 15, 1963).

Silicon {1 1 1} slices were obtained from spin-pulled crystals doped with $10^{17}$ B atoms $cm^{-3}$. The dislocation densities were below $10^4$ $cm^{-2}$. The crystals also contained approximately $10^{18}$ O atoms $cm^{-3}$. Small disks of 0.125 in. diameter and 0.015 in. thickness were etched thin in the central 0.0625 in.-diameter region. These disks were sufficiently thin for electron transmission (1000–1500 Å) yet firmly supported by a thick ring. These sample disks were inserted next to the core of the Battelle research reactor (swimming pool) and exposed to bombardment by $5 \times 10^{14}$ fast neutrons $cm^{-2}$. Electron micrographs revealed damage tracks produced by the bombardment. Most tracks exhibit a central high-contrast image with surrounding low-contrast image cloud. Possible particles that could have produced the tracks were discussed. Atoms present in significant quantity in or nearby the film were Si, O, B, N, C, and H. The characteristics of the tracks eliminated most of the particles in question. It was thought most probable that the track was produced by a primary knock on Si atom either inside the film or at the surface. The track was thought to be a temperature spike produced by the knockon atom. (C.E.S.)

**11273** EFFECT OF THERMAL NEUTRON IRRADIATION ON THERMOCOUPLES AND RESISTANCE THERMOMETERS. C. W. Ross. Commun. Electronics, No. 61, 192-6(July 1962).

The effects of radiation environment on the accuracy of thermocouples and resistance thermometers were studied. Discussion is given on transmutations due to neutron absorption; lattice defects produced by elastic neutron collisions; error due to gamma heating; radiation effects on insulation; and miscellaneous nonnuclear effects. When possible, results were obtained on a theoretical and nonnuclear experimental basis. This method has the advantage of permitting extrapolation of test data beyond that of the given test environment and increases the reliability of significance attached to a limited amount of test data. (P.C.H.)

**11274** IRRADIATION OF AN Fe–Ni (50-50%) ALLOY WITH 1-Mev ELECTRONS. William Chambron, Daniel Dautreppe, Louis Néel, and Jean Paulevé. Compt. Rend., 255: 2037-9(Oct. 22, 1962). (In French)

A polycrystalline sample of Fe–Ni was irradiated with 1-Mev electrons at 280°C under a magnetic field. The uniaxial magnetic anisotropic energy, obtained as a function of the dose, showed the disorder-order transformation from the acceleration of diffusion processes created by faults created during irradiation. The kinetics of the isothermal anneal at 120°C after a bombardment at 20°C with a dose of $4 \times 10^{18}$ $e/cm^2$ was studied with the application of a magnetic field in the same direction as the field applied during the irradiation. The increase of the anisotropy energy was measured as a function of time. The kinetics of anneal is very well represented by a logarithmic function as in the case of neutron irradiation. (J.S.R.)

**11275** A STUDY OF POSITRON-ELECTRON ANNIHILATION IN ORDERED ALLOYS. I. Ya. Dekhtyar, S. G. Litovchenko, and V. S. Mikhalenkov (Inst. of Physics of Metals, Academy of Sciences, Ukrainian SSR). Doklady Akad. Nauk SSSR, 147: 1332-5(Dec. 21, 1962). (In Russian)

The previously developed method of electron-positron annihilation (see Stewart, Canad. J. Phys., 35: 168(1957)) was used to study the change in maximum momentum $p_m$ of the conduction electrons in the ordered alloys $Ni_3Mn$, $Cu_3Au$, and CuAu. The ordered $Cu_3Au$ alloy has the same structure as $Ni_3Mn$, but the ordered CuAu alloy has a lamellar structure. The alloys were ordered by annealing at 360°C for 120 hours, and were put into a state of disorder by quenching from 900°C. The angular distribution of annihilation photons was the same in the ordered and disordered states for $Cu_3Au$ with a value of $p_m = 8.05 \times 10^{-3}$ mc units. The value of $p_m$ in $Ni_3Mn$ was $8.52 \times 10^{-3}$ mc units in the disordered state, and $8.04 \times 10^{-3}$ mc units in the ordered state (about 6% less). The maximum momentum was $8.0 \times 10^{-3}$ mc units for the ordered state of CuAu, and $8.9 \times 10^{-3}$ mc units for the disordered state (a difference of about 11%). A decrease in lattice energy stabilized the ordered state of $Cu_3Au$, but a decrease in the Fermi energy explained the stability of the ordered state in CuAu. A redistribution of s- and d-electrons in $Ni_3Mn$, which is expressed by an increase in the saturation magnetization, stabilized the ordered phase in this case. (TTT)

**11276** INVESTIGATIONS ON THE RADIATION STABILITY OF SYNTHETIC ION EXCHANGERS (WOFATITES). L. Wuckel, E. Niese, and W. Koch (Institut für Angewandte Physik der Reinstoffe, Dresden). Isotopen Tech., 2: 303-6 (1962). (In German)

In the framework of studies on the radiation stability of various materials used in nuclear technology artificial

native ion exchangers (wofatites) were tested. The results of these studies show that wofatites under common radiation doses satisfy the requirements set. (tr-auth)

**11277** GAMMA EFFECTS ON DIELECTRIC PROPERTIES OF INSULATING MATERIALS. II. POLYETHYLENE. B. I. Vorozhtsov, V. M. Nesterov, and N. I. Olshanskaya (Tomsk State Univ., USSR). Izv. Vysshikh Uchebn. Zavedenii, Fiz., No. 5, 34-7(1962). (In Russian)

In spite of various changes induced in polyethylene by γ irradiation the material is considered radioresistant and can be recommended for equipment operating under γ exposures to 3000 r/min. (R.V.J.)

**11278** DIELECTRIC LOSSES INDUCED IN CRYSTALLINE POLYMERS BY IONIZING RADIATION. N. I. Olshanskaya and B. I. Vorozhtsov (Tomsk State Univ., USSR). Izv. Vysshikh Uchebn. Zavedenii, Fiz., No. 5, 150-5(1962). (In Russian)

Studies were made of dielectric losses induced in technical polyethylene, polyamide-68, and fluroplastic-3 by γ- and ultraviolet radiations. It was observed that the tangent angle of losses is higher with higher crystallization in the specimen; the variability is reversible in character. The exposure also induces variations in conductance and dielectric polarization. (R.V.J.)

**11279** RADIATION-INDUCED CROSSLINKING OF POLYMERS AND POLYMERIZATION OF PARAFFINIC HYDROCARBONS. W. L. McCubbin and J. J. Weiss (Univ. of Newcastle, Newcastle upon Tyne, Eng.). J. Appl. Polymer Sci., 6: S68-9(Nov.-Dec. 1962).

A critical review is given of 2 separate studies previously made on the decay of electron spin resonance amplitude at room temperature subsequent to irradiation at liquid nitrogen temperature. The shape of the decay curve shows the two studies to be in apparent disagreement. It was concluded that the studies do not provide an adequate basis for a crosslinking mechanism unless the experimental findings are shown to be considerably in error. It could be that the processes previously described occurred in irradiated polyethylene, but their relevance to the phenomenon of crosslinking has not been established. (P.C.H.)

**11280** ENERGY DEPOSITION IN POLYMERS BY REACTOR RADIATION. A. Jacobs and D. E. Kline (Pennsylvania State Univ., University Park). J. Appl. Polymer Sci., 6: 605-12(Nov.-Dec. 1962).

The temperature distribution in small polymer samples was used to determine the rate of energy deposition by nuclear reactor radiation as a function of distance from the reactor core. Polyethylene, polystyrene, poly(hexamethylene adipamide), polytetrafluoroethylene, and polymerized epoxy resin were employed as specimen materials. Some of the results are compared to calculated values based on a simplified radiation spectrum. The values are in good agreement, and it is thus suggested that the calculational method is valid for estimating the integral epithermal neutron flux and the relative energy deposition in different polymers. (P.C.H.)

**11281** MECHANISM OF DISCOLORATION OF IRRADIATED POLYVINYL CHLORIDE. Shun-ichi Ohnishi, Yoshiharu Nakajima, and Isamu Nitta (Japanese Assn. for Radiation Research on Polymers, Osaka, Japan). J. Appl. Polymer Sci., 6: 629-38(Nov.-Dec. 1962).

The radiation chemical process in polyvinyl chloride was studied by means of electron spin resonance, optical spectroscopy, and measurement of gas evolution. The chief technique was to irradiate samples at −196°C and then follow the change or changes with rising temperature. Resonance results showed that, on irradiation, several primary radicals, such as $-CH_2-CH-CH_2-$ and $-CHCl-CH-CHCl-$, were produced. Among them some $-CH_2-CH-CH_2-$ radicals could recombine to form crosslinks during irradiation even at −196°C. A mechanism for the discoloration of PVC, based upon results obtained by the three different methods, was postulated. Discoloration is caused by the formation of polyenyl radicals or polyene molecules of considerable conjugation lengths, some as long as 9 conjugated double bonds. Polyenyl radicals are produced as a result of a thermally induced secondary reaction of the $-CHCl-CH-CHCl-$ radical, above −70°C, thereby accompanied by hydrogen chloride detachment following the so-called zipper mechanism. An equation relating the pressure of evolved HCl to the reaction temperature was derived by a simple kinetic treatment of the zipper reaction. Some effect of heat treatment and increasing dose on discoloration is discussed. (P.C.H.)

**11282** β-ABSORPTION AND GLASS TRANSITIONS IN POLYMERS. R. Zannetti, P. Manaresi, and L. Baldi (Istituto Ricerche Idrocarburi, Società Montecatini, Ferrara, Italy). J. Polymer Sci., 62: S33-8(Dec. 1962).

Beta absorption and glass transitions were investigated in specimens of amorphous polystyrene (free-radical polymerization), cis-1,4-polybutadiene, atactic poly-α-butene, atactic polypropylene, natural rubber, branched polyethylene, polyethylene terephthalate, and ethylene–propylene and ethylene–1-butene copolymers at different ethylene contents. The glass transition temperature values are tabulated. In polyethylene terephthalate and amorphous polystyrene, the transmitted activity-temperature coefficient changed, at the transition, in sign as well as in numerical value. All other polymers observed showed behavior corresponding to density changes. (P.C.H.)

**11283** SOLID-STATE POLYMERIZATION OF ACENAPHTHYLENE INDUCED BY IONIZING RADIATION. Catherine S. Hsia Chen (American Cyanamid Co., Stanford, Conn.). J. Polymer Sci., 62: S38-42(Dec. 1962).

The radioinduced polymerization of commercial and recrystallized solid acenaphthylene was undertaken in air, under nitrogen, and in vacuum. The results show that the per cent polymerization of commercial acenaphthylene in air versus total dose after an induction is directly proportional to the total dose. The overall rate of polymerization under nitrogen for acenaphthylene twice recrystallized from methanol was significantly slower than for commercial. The difference in the rates suggests that impurities, including oxygen, increase the rate of polymerization. The prepared polyacenaphthylene was shown to be amorphous by x-ray diffraction. The color of the polymer depends on the molecular weight. (P.C.H.)

**11284** X-RAY INDUCED POLYMERIZATION OF VINYL IODIDE IN SOLUTION. Jan A. Herman and Pierre Roberge (Laval Univ., Quebec). J. Polymer Sci., 62: S116-18(Dec. 1962).

Vinyl iodide solutions, which were kept in the dark and in the absence of oxygen, were irradiated at room temperature. Methylene chloride, chloroform, and carbon tetrachloride were chosen as solvents in order to protect the polymerization to a certain extent from the inhibiting action of iodine produced by monomer decomposition. Under these conditions the irradiation of dilute solutions of vinyl iodide led to the formation of polymer, although the yield was poor. Some properties of the polymer are given along with discussion on the infrared spectrum. (P.C.H.)

**11285** GAMMA RADIATION INDUCED POLYMERIZATION OF ALPHA-METHYLSTYRENE. THE EFFECT OF

WATER ON MOLECULAR WEIGHT DISTRIBUTION. C. G. Baumann and D. J. Metz (Brookhaven National Lab., Upton, N. Y.). J. Polymer Sci., 62: S141-4(Dec. 1962). (BNL-5838)

The effects of water on molecular weight distribution in the radioinduced polymerization of $\alpha$-methylstyrene were studied. It was found that the methanol-soluble fraction can represent anywhere from 80% down to <1% of the total conversion of monomer. The lowest amount of methanol-soluble material was obtained with exhaustively dried starting material, and the highest with samples that were equilibrated with atmospheric water. The infrared spectrum of the methanol-soluble fraction exhibited two easily observable absorptions at 2.76 and 6.30 $\mu$, which may be attributed to an OH stretching and an OH bending mode, respectively. This might be taken to indicate that the role of water is one of causing fairly rapid termination (before more than 5 addition steps) of the chain process. It was concluded that water is capable of terminating polymeric chains at low stages of the growth process and also appears to affect the overall conversion process, by some more subtle mechanism. The effects of temperature and drying agents on $\alpha$-methylstyrene are also discussed. (P.C.H.)

**11286** RESISTANCE TO IRRADIATION OF INSULATING SILICATE-FILLED RUBBER VULCANIZATES. G. A. Blokh, M. S. Khloplyankina, A. P. Yemel'yanova, A. P. Pisarenko, and V. L. Karpov. Kauchuk i Rezina, No. 10, 26-8(Oct. 1962).

The effect of ionizing radiation on the properties of silicate rubber vulcanizates containing various amounts of silicate fillers introduced into the latex and coprecipitated with rubber was studied. Experiments were conducted with rubbers obtained from butadiene-styrene latex with 22 to 57 parts silicate filler and from latex with 20 parts polystyrene latex and 19 to 30 parts silicate filler. The vulcanizates were made from mixes containing (in addition to varying filler amounts): rubber, 100 parts; paraffin, 2; rosin, 5; and thiuram, 1.5. The vulcanizates were $\gamma$ irradiated from a $Co^{60}$ source of 21000 g-equiv Ra with doses of 50 to 100 megarad. Irradiation lowered the tensile strength, elongation, and residual elongation of the vulcanizates but increased their hardness. However, rubber vulcanizates containing 22 to 42 parts silicate filler irradiated with a dose of 50 megarad were shown to exhibit satisfactory mechanical properties, such as tensile strength, 80.2 to 88.7 $kg/mm^2$; and elongation, 470 to 520%. The addition of 20 parts polystyrene latex did not improve the resistance of vulcanizates to irradiation. The introduction of 100 parts chalk or talcum into the rubber mixes sharply reduced the resistance. All the vulcanizates irradiated with a dose of 100 megarad were shown to lose strength and elasticity. (OTS)

**11287** NEUTRONS EMBRITTLE REACTOR VESSELS OF CARBON STEEL. Donald W. McLaughlin (Mechanical Tech. Inc., Latham, N. Y.). Nucleonics, 21: No. 2, 36-41 (Feb. 1963).

Test data indicated that reactor-vessel steels might become brittle at temperatures as high as 200–400°F after exposure to $0.5 - 2 \times 10^{19}$ $n/cm^2$ (neutrons of >1 Mev). To resolve this safety question metallurgical changes were defined in terms of the fast-neutron exposure, temperature and stresses, criteria for operating vessels safely at temperatures near or below the nil-ductility transition temperature (NDT), and fast neutron fluxes to which the vessels were exposed. This was done accurately enough to be able to predict the vessel condition after some period of operation. Prolonged exposure to fast neutrons hardened and strengthened steel, but also decreased ductility. The confidence with which NDT-shift data can be used to set reactor operating limits related directly to the accuracy of measuring or calculating neutron flux at the vessel wall. Activation dosimeters for measuring neutron fluxes were used because they are small, self-contained, and relatively inexpensive. A series of dosimeters with closely spaced thresholds, physical properties that are compatible with reactor-experiment conditions, and that produce isotopes with long half lives were needed to integrate neutron exposure over a several month experiment. Specimens of vessel material were placed inside the vessel adjacent to the wall, or at a point of similar neutron flux and temperature, and tested periodically to tell the operator the vessel condition. (C.E.S.)

**11288** RADIATION EFFECTS IN DIAMONDS. A. A. Schulke (Argonne National Lab., Ill.). Nucleonics, 21: No. 2, 68-70(Feb. 1963).

Irradiation with alpha particles, protons, deuterons, and neutrons gave diamonds some shade of green. The final color was determined by the length of exposure and the mixture of this color with the natural color of the stone. Heat treatment changed these colors to a new range. Radiation-induced color was not removed by heat. Conductivity was a convenient test for distinguishing between rare blue diamonds and those electron-irradiated to a blue color. (C.E.S.)

**11289** DE-EXCITATION EFFECT OF X-RAYS. G. M. Ivanii. Opt. Spectry. (USSR) (English Transl.), 13: 353-4 (Oct. 1962).

The existence of the de-excitation effect of x rays is demonstrated directly through the use of x rays of different wavelengths and their effect on the ZnS–Cu($5 \times 10^{-4}$ g/g) phosphor. When the phosphor was irradiated first with rays of long wavelength $\lambda_1$ and then short wavelength $\lambda_2$, the intensity of x-ray luminescence and light sum of decay $L_d$ and thermal de-excitation $L_T$ were exactly equal to the corresponding values for only one irradiation of short wavelength $\lambda_2$. In another case, when the phosphor was irradiated first with short wavelength radiation $\lambda_2$ and then with a longer wavelength $\lambda_1$, the intensity of the x-ray luminescence after the transition decreased slowly, gradually approaching the value observed during irradiation with wavelength $\lambda_1$. Thus, the results demonstrate the existence even in the x-ray region of the dependence of the accumulated light sums on the wavelength of the exciting radiation. This is a consequence of the de-excitation effect of the exciting radiation. (P.C.H.)

**11290** ENERGY TRANSPORT IN ELECTRON BOMBARDED CADMIUM SULFIDE SINGLE CRYSTALS. C. E. Bleil (General Motors Corp., Warren, Mich.). Phys. Chem. Solids, 23: 1729-36(Dec. 1962).

It is demonstrated that for single crystals of cadmium sulfide under bombardment by electrons of energies from 1 to 50 kev x rays and excitons can play a significant role in the transport of energy. Experimental evidence demonstrating the separate roles of charge carriers, visible light, x rays and excitons is given. (auth)

**11291** DECAY OF TRAPPED-FLUX IN A SUPERCONDUCTING RING SUBJECTED TO IRRADIATION BY $\alpha$-PARTICLES FROM A $Po^{210}$ SOURCE. P. De Feo and G. Sacerdoti (Laboratori Nazionali di Frascati, Rome). Phys. Letters, 2: 264(Oct. 15, 1962). (In English)

Measurements are reported on the trapped-flux in a lead superconducting ring under bombardment of $\alpha$ particles. The experimental apparatus is shown. The source and lead ring were both prepared by electrolytic deposition. The trapped flux was nearly 48 Maxwell. (W.D.M.)

# PHYSICS

## General and Miscellaneous

*Refer also to abstract 12011.*

**11292** (AD-277043) RARE EARTH CHALCOGENIDES. Final Report, August 1, 1960–June 30, 1961. H. M. Muir (Research Chemicals. Div. of Nuclear Corp. of America, Phoenix, Ariz.). June 1961. Contract NObs-84088. 47p. (RC-180)

Eleven rare earth chalcogenides, as well as one rare earth ternary chalcogenide, were investigated to evaluate their potential as thermoelectric materials. The compounds are the sesquiselenides of Y, La, Pr, Sm, Er, Yb, and Gd; the Gd and Y sesquisulfides and sesquitellurides; and the ternary Dy sesquitelluride-sesquiselenide. Specific processing parameters developed for gadolinium sesquiselenide are defined and their effects on electrical and physical characteriestics are described. A tentative correlation between the observed second phase and a vitreous state in materials having anomalous conduction is presented. (auth)

**11293** (AD-277122) THERMOELECTRICITY QUARTERLY PROGRESS REPORT NO. 4, SEPTEMBER 11, 1961–NOVEMBER 11, 1961. (Westinghouse Electric Corp. Research Labs., Pittsburgh). Contract NObs-84317. 228p.

Eight papers having a direct bearing on the thermoelectric project are included. The role of Se vapor pressure in the formation of Ag-doped MnSe was studied. The effects of doping on the vapor pressure of a thermoelectric material were investigated toward the solution of practical problems of thermocouple encapsulation. Preparations and properties of some rare earth semiconductors and certain mixed hydride–chalcogenide rare earth compounds were investigated. Directions are given for the preparation of the optimumly doped thermoelectric material CeS 1.38 and for many other rare earth compounds which were investigated as possible thermoelectric elements. Solid solution studies were made on some post-transition metal tellurides of the rock-salt structural type and on electrical properties of $T_1SbTe_2$–$T_1BiTe_2$ solid solutions. A technique for pulling single crystals of volatile materials, a rotating sample method for measuring the Hall mobility, and a steady-state comparative apparatus for measuring thermal conductivity between 100 and 800°C are described. (auth)

**11294** (AD-277223) THERMOELECTRICITY QUARTERLY PROGRESS REPORT NO. 2, JULY 1, 1961–OCTOBER 1, 1961. (Westinghouse Electric Corp. Research Labs., Pittsburgh). Contract NObs-84687. 61p.

An evaluation was made of the proposal that narrow band semiconductors offer good possibilities as thermoelectric elements. It is shown that Tz goes to zero as the band width goes to zero. Results of recent studies on the thermal conductivity of the Ge–Si alloys are discussed. Present theory of lattice thermal resistance is seen to be in reasonable agreement with the experiment. Schroeder criticized the paper of Cosgrove, McHugh, and Tiller in which they explained the variation of thermoelectric properties with growth rate of $Bi_2Te_3$. It is pointed out that the criticism is invalid. A discussion of the definitions of thermoelectric effects in non-linear junctions is given. (auth)

**11295** (AD-277713) LOW TEMPERATURE THERMIONIC CONVERTERS. Quarterly Technical Progress Report No. 2, March 1, 1962–June 1, 1962. (Ford Instrument Co., Long Island City, N. Y.). June 1962. Contract AF33(657)-7663. 11p.

Research in the development of low-temperature thermionic converters during the period has centered on improving the reliability of refractory metal envelopes relative to grain growth and subsequent permeability and on improving the output power density of the metal ceramic cells. New fabrication techniques for pure molybdenum and use of molybdenum alloys as well as tungsten have produced considerable improvement in the grain growth situation. Performance of new metal-ceramic cells that resulted from an analysis of previous cells is also evaluated. Geometry changes and new fabrication techniques offer improved performance. Tests on the various components are described, and the results are given. (D.C.W.)

**11296** (AD-278352) STUDY OF SEMICONDUCTING PROPERTIES OF RARE-EARTH METALS AND COMPOUNDS. Interim Scientific Report No. 3, June 1, 1961–May 15, 1962. J. F. Miller, F. J. Reid, L. K. Matson, and R. C. Himes (Battelle Memorial Inst., Columbus, Ohio). June 1, 1962. Contract AF33(616)-7321. 40p.

Various methods for the growth of crystals of rare-earth selenides, tellurides, and arsenides were investigated. Sm metal was purified by distillation and subsequent condensation as a solid. Analysis of crystal-structure data for the Nd, Gd, and Er sesquiselenides and sesquitellurides indicates that the $Th_3P_4$ structure becomes unstable at anion-cation radius ratios above 2.2. Electrical-property studies indicate that, in the Nd–Te and Gd–Te systems, the MX and $M_3X_4$ compositions resemble metals and semimetals, while properties of the $M_2X_3$ compositions are similar to those of typical semiconductors. The monoselenides and monotellurides of Sm and Yb have apparently intrinsic high-negative temperature coefficients of resistance. Room-temperature resistivity and the activation energy for conduction in SmSe were 2000 ohm-cm and 0.7 ev, respectively. Specimens with room-temperature resistivities ranging from 3700 to $10^{-4}$ ohm-cm were prepared by alloying high-resistivity YbSe with low-resistivity NdSe. (auth)

**11297** (AE-95) THE PARAMAGNETISM OF Mn DISSOLVED IN $\alpha$ AND $\beta$ BRASSES. H. P. Myers and R. Westin (Aktiebolaget Atomenergi, Stockholm). Dec. 1962. 13p.

Paramagnetic susceptibility measurements were made on $\alpha$ and $\beta$ brasses containing ~1 wt% Mn. The susceptibility varied with temperature according to the Curie-Weiss law and the Curie constant and thereby the Bohr magneton number per Mn atom was determined. Interpreted in terms of valency, Mn monovalent in copper has a valency in $\alpha$ brass which decreases progressively with zinc content attaining the value 0.58 at the limiting $\alpha$ composition. Mn in $\beta$ brass exhibits a valency 0.8. These results are not in keeping with previous values for the valency of manganese as determined from phase boundary relationships and electron to atom ratios. (auth)

**11298** (AFCRL-62-456) EFFECTIVE TRANSMISSION OF THERMAL RADIATION FROM NUCLEAR DETONATIONS IN REAL ATMOSPHERES. Air Force Surveys in Geophysics No. 144. John P. Cahill, Hervey P. Gauvin, and John C. Johnson (Air Force Cambridge Research Labs. Geophysics Research Directorate, Bedford, Mass.). Feb. 16, 1962. 72p. (AD-277005)

An analysis was made to provide as simple a technique as practicable for the prediction of thermal inputs to targets from nuclear weapons, consistent with a moderate degree of confidence, for use in the field with available meteorological data. A study was made of the geographical factors influencing the transmission of thermal radiation from nuclear weapons through cloudless atmospheres. Results are presented as the ratio of the irradiance received on a 2 pi detector in the presence of an attenuating atmosphere to the irradiance expected on the same detector in free space. The primary influencing factors considered are the scattering and absorbing properties of the atmosphere, reflection from the underlying surface, the temperature-time characteristics of the source, and the source-detector geometry. The results are presented graphically, with contours of t (effective transmission) for each atmospheric model studied. Ground level visual ranges of 2, 10, and 50 nautical miles were incorporated into both wet and dry atmospheres, which in turn were terminated with a surface having albedos of either 0, 0.2, or 1.0. (auth)

**11299** (ANL-6612) PHYSICS DIVISION SUMMARY REPORT, SEPTEMBER–OCTOBER 1962. (Argonne National Lab., Ill.). Contract W-31-109-eng-38. 29p.

Angular distributions of the spectra were measured for the $F^{19}(d,He^3)O^{18}$ and $Al^{27}(d,He^3)Mg^{26}$ reactions at 21.6 Mev and the results interpreted in terms of $O^{18}$ and $Mg^{26}$ excitations. The operation of the Mark I and II atomic-beam machines is described briefly, and nuclear spin flop measurements are reported. Reduced transition probabilities were obtained for magnetic dipole transitions from the ground properties of angular distributions of decay products from $K^- + p \rightarrow \Xi^- + K^+$, $\Xi^- \rightarrow \Lambda^0 + \pi^-$ were studied, and it is shown that $s = \frac{1}{2}$ for $\Xi^-$. (D.L.C.)

**11300** (ASD-TDR-62-214) FLAT-PLATE SOLAR THERMOELECTRIC CONVERSION PANELS. Final Report. Arthur N. Himle, Daniel S. Brush, John B. Roes, and Edward L. Brady (General Atomic Div. General Dynamics Corp., San Diego, Calif.). Mar. 19, 1962. Contract AF33(616)-7676. 47p.

Procedures were developed for the construction of a lightweight solar energy converter, using thermoelectric materials sandwiched between flat sheets of aluminum. Two panels, each one foot square, were delivered to the Flight Accessories Laboratory, Aeronautical Systems Division. Each panel contains 153 n-type PbTe elements and 153 p-type ZnSb elements, arranged in eighteen alternating rows of seventeen elements each. According to measurements made on test panels constructed in a similar fashion, the delivered panels are capable of an output of at least 1.33 $w/ft^2$ when subjected to an incident energy of 1400 $w/m^2$, which is equal to the solar energy intensity at the Earth's distance from the sun. At this output, the solar panel weighs 96 pounds per electrical kilowatt. The observed output is lower than is calculated from the properties of the materials used; however, it is anticipated that improved performance can be obtained in future panels. (auth)

**11301** (ASD-TDR-62-858) A COMPUTER PROGRAM FOR THE MATANO ANALYSIS OF BINARY DIFFUSION DATA. Craig S. Hartley and Kenneth Hubbard (Aeronautical Systems Div. Metals and Ceramics Lab., Wright-Patterson AFB, Ohio). Sept. 17, 1962. 65p.

A computer program for the Boltzmann-Matano solution to Fick's second law in semi-infinite binary diffusion couples is presented. The program is written in FORTRAN for the IBM 7090 digital computer. An error function curve fit is used to interpolate between and smooth experimental data, and the calculations performed on the regenerated data. Examples are given of application of the program to incremental couples with no intermediate phases and to pure metal couples with and without intermediate phases. Phase boundaries in couples with intermediate phases can also be obtained with a high degree of accuracy. By substituting lattice spacings for ordinary distance units, a correction for molal volume change due to composition differences can be programmed. (auth)

**11302** (ASD-TR-61-150(Pt.II)) PROPELLANTS FOR ELECTRICAL PROPULSION ENGINES OF THE CONTACT OR BOMBARDMENT ION TYPE. SECOND ANNUAL (FINAL) REPORT. (Rocketdyne. Div. of North American Aviation, Inc., Canoga Park, Calif.). Nov. 16, 1962. Contract AF33(616)-7063. 139p. (R-3556)

Efforts devoted to an investigation of materials and methods for producing molecular ions and a colloidal ion beam suitable for use in electrical propulsion devices are reported. The molecular compounds were selected for study primarily on a basis of expected favorable ionization characteristics and high structural stability to fragmentation. Limiting stable molecular structures were found for several classes of compounds. The experimental techniques for determining physical and chemical properties of candidate materials are outlined, and the experimental results are combined with data from the literature to complete the propellant study program. A theoretical analysis of a colloid producing system which utilizes a convergent-divergent nozzle for rapid condensation of propellant is presented. Equations are given which may be used to optimize the design and operation of a system which produces colloidal particles from condensable vapors. Electrical charging of the droplets is accomplished by ionizing a fraction of the propellant vapor prior to expansion through the nozzle. A graphical approach for obtaining approximate thermodynamic conditions necessary to adiabatically condense propellant vapors in a typical colloid generating system is introduced. Experimental results from operation of a charged, Hg colloid generator are presented. The theoretical and graphical methods may be extended to other propellants if they possess suitable thermodynamic and physical properties. (auth)

**11303** (HW-75228) PHYSICS RESEARCH QUARTERLY REPORT, JULY–SEPTEMBER 1962. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Oct. 15, 1962. Contract AT(45-1)-1350. 57p.

A detailed comparison of recent data on differential scattering cross sections in water with Nelkin's theoretical kernel indicates that modification of the original parameters should be made. The modifications are in progress. In work on the effects of scatterers on criticality, it was found that criticality of a hydrogenous system is a function of the scatterers present. In other work, a two-group theory of exponential pile flux distributions was investigated and found to account for discrepancies between data and a fitted curve in exponential pile analysis. Measurements of B and Pu masses using the PCTR revealed that quantities of B, of the order of 0.01 g, can be measured to an accuracy of ±3% while 1.1 g Pu can be measured to an accuracy of ±9%. Criticality experiments were continued with plutonium nitrate solutions in a 14-in. diam. water-reflected stainless sphere in which criticality data were obtained as a function of the Pu concentration and solution acidity. Information and data obtained in an experiment on the limiting critical concentrations of $U^{233}$ and $Pu^{239}$ in aqueous solutions are given. (J.R.D.)

**11304** (HW-75499) ULTRASONIC LAMB-WAVE PROPAGATION MODELS FOR NONDESTRUCTIVE TESTING APPLICATIONS. C. E. Fitch (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Oct. 1962. Contract AT(45-1)-1350. 39p.

Studies were carried out on the ultrasound propagation in thin Zircaloy specimens. Basic Lamb wave propagation formulas are presented, and a technique was developed for separating Lamb waves into longitudinal and shear wave components. Sound leakage from the end of Zircaloy plates vibrating in the Lamb wave domain was observed using the Schlieren image technique. The above effects are discussed relative to nondestructive testing of Zircaloy tubing. (D.L.C.)

**11305** (IFT-1) PLANCK'S CONSTANT AND THE THEORY OF THE RED SHIFT. Leopold Infeld (Warsaw. Univ. Inst. of Theoretical Physics and Polish Academy of Sciences. Inst. of Physics, Warsaw). Jan. 1962. 13p.

Treatment of the motion of a light ray along a geodesic line in a static field reveals that Planck's constant ceases to be a constant in a gravitational field. This result is generalized to de Broglie's theories, yielding results that embody the theory of the red shift. (D.C.W.)

**11306** (IS-473) ELECTRON REQUIREMENTS OF BONDS IN METAL BORIDES. Robert W. Johnson and A. H. Daane (Ames Lab., Ames, Iowa). [May 28, 1962]. Contract [W-7405-eng-82]. 30p.

Electrical measurements were made on $CaB_6$, $SrB_6$, $BaB_6$, $YB_2$, $YB_4$, $YB_6$, and $YB_{12}$ for the purpose of testing models of the electronic structure of the boron atoms in the four boride types represented. The compounds $CaB_6$, $SrB_6$, and $BaB_6$ were found to be semiconductors. The Hall coefficients of $YB_2$, $YB_6$, and $YB_{12}$ were measured and found to correspond to one free electron per yttrium atom in each compound. The Hall coefficient of $YB_4$ was also measured, but could not be interpreted because the free electron theory does not provide a theoretical value for comparison with experiment. The results are in agreement with the models proposed. (auth)

**11307** (JINR-P-1009) OPREDELENIE PARAMETROV OBOBSHCHENNOI DIFRAKTSIONNOI MODELI YADRA PRI 660 Mev. (Determination of the Parameters of a Generalized Nuclear Diffraction Model at 660 Mev). L. S. Azhgirei and S. B. Nurushev (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1962. 8p.

Results of an investigation are presented in which the relations between the nucleon-nucleus scattering amplitudes and the parameters of the generalized diffraction model at 600 Mev were examined. The effects of the spin-orbital interaction on the opacity function value are discussed. (J.R.D.)

**11308** (JINR-P-1113) PRIMENENIE METODA STATSIONARNOI FAZY K RESHENIYU KINETICHESKIKH URAVNENII. (Application of Stationary Phase Method to the Solution of Kinetic Equations). L. G. Zastavenko and A. Chilok (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics). Oct. 24, 1962. 9p.

The application of the stationary phase method makes it possible to obtain a solution of the kinetic equations similar to those encountered in the multiple scattering theory for large scattering angles. (auth)

**11309** (LA-2750) A PROPOSED MODIFICATION OF THE AVAILABLE MOMENTUM REGION IN THOMAS-FERMI THEORY. John F. Barnes (Los Alamos Scientific Lab., N. Mex.). Sept. 1962. Contract W-7405-eng-36. 148p.

A "quantum correction" of the statistical model of the atom was obtained by modifying March and Plaskett's region of integration in the $(n,l)$, or quantum number, plane. Integrations over the plane lead, in the unmodified case, to the Thomas-Fermi density expression and energy equation. Integrations over the modified region are shown to produce a modified Thomas-Fermi expression for the electron density, and a correction to the kinetic energy. The latter correction shows a similarity to the Weizsäcker correction, but is smaller by a slowly changing factor of the order of ten. A modified Thomas-Fermi-Dirac equation was derived by the standard variational procedure. Numerical solutions of the equation were obtained which yield atomic binding energies in much better agreement with experimental values than those of the unmodified theory. The pressure-compression values, however, are but slightly different from those on the unmodified model. (auth)

**11310** (LA-2806) THEORY OF CORRESPONDENCE BETWEEN FLUID DYNAMICS AND PARTICLE-AND-FORCE MODELS. Francis H. Harlow (Los Alamos Scientific Lab., N. Mex.). Nov. 1962. Contract W-7405-eng-36. 28p.

Particle-and-force models for high-speed-computer calculations of fluid dynamics problems have several conceptual advantages over most presently used techniques; in addition, test calculations with several versions indicated considerable promise for wide application. For these reasons, an analysis was undertaken to demonstrate the basis for expecting success in one class of such models (the completely statistical class) and in addition to show how to choose the interparticle force function to correspond to a given material equation of state. The method of analysis employs a many-particle distribution function equation whose reduction is accomplished through the assumption of two-body forces and of strong correlations with the mean. Primary results include correspondence equations between conservative force function and equation of state, and between dissipative force function and viscous stress. Solutions are given for the first type of correspondence equation, and comparisons are made with previous heuristic studies. (auth)

**11311** (LAMS-2796) QUARTERLY STATUS REPORT OF THE LASL PLASMA THERMOCOUPLE DEVELOPMENT PROGRAM FOR PERIOD ENDING OCTOBER 20, 1962. (Los Alamos Scientific Lab., N. Mex.). Nov. 1962. Contract W-7405-eng-36. 12p.

A thermionic converter was constructed to evaluate the effect of radiation shields in the interelectrode space. No significant difference was found in the total power and short-circuit currents with and without the radiation shield, although there was evidence that the cell efficiency was higher at intermediate emitter temperatures (1200 to 1800°C). An in-pile test was made with a cell containing a radiation shield surrounding the emitter and connected electrically to the collector. The cell for spectroscopic studies of cesium plasma was assembled and two runs completed without cesium. Metallographic examinations were made of hot-pressed UC–ZrC fuel pins. An electrochemical technique was devised for cutting a fuel pin from a solid UC-ZrC cylinder. A carbide fuel pin, maintained at 700°C, brazed with V to a Nb collector underwent a 400 hr test in Cs vapor at 400°C. Potted electrical coils withstood 25 pulses with no visible damage. (M.C.G.)

**11312** (LNF-62/106) COMPLETELY SPACE CHARGE LIMITED CURRENTS IN SUPERFLUID HELIUM: A METHOD FOR THE MEASUREMENT OF THE IONIC MOBILITIES IN THE VICINITY OF THE LAMBDA-POINT.

Note No. 173. A. L. Bartoli and F. Scaramuzzi (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). Dec. 13, 1962. 21p.

A new method for measuring mobility of helium ions in the vicinity of the lambda point is described. Measurements of the voltage current characteristics of a diode under conditions of complete space charge limitations replace the usual time-of-flight measurements. Mobilities of positive ions in liquid helium-4 as a function of temperature are displayed and compared with other values. (D.C.W.)

**11313** (MND-2945-1) DEVELOPMENT OF AN ENCAPSULATED THERMIONIC POWER GENERATOR. Quarterly Technical Progress Report, November 1–January 31, 1963. (Martin-Marietta Corp. Aerospace Div., Baltimore). Feb. 15, 1963. Contract AF33(657)-10077. 15p.

The engineering design of the double diode thermionic power generator was completed. Fabrication of several component parts was initiated. The parts for the fueled emitters are almost completely fabricated with only assembly and final machining remaining. The manufacture of other generator components including the collector temperature control assembly and the ceramic-to-metal seals was initiated. The engineering design of the clad fuel elements was completed and the first element, similar in configuration to the fueled emitter, was fabricated. This element will be used to determine the changes in the vacuum emission characteristics over a 200 hour test period. The vacuum test chamber was fabricated and is undergoing preliminary outgassing. (auth)

**11314** (NAA-SR-7288) STATISTICAL ANALYSIS OF SNAP 10A THERMOELECTRIC CONVERTER ELEMENT PROCESS DEVELOPMENT VARIABLES. S. H. Fitch and J. W. Morris (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Dec. 15, 1962. Contract AT-11-1-GEN-8. 41p.

Statistical analysis, primarily analysis of variance, was applied to evaluate several factors involved in the development of suitable fabrication and processing techniques for the production of lead telluride thermoelectric elements for the SNAP 10A energy conversion system. The analysis methods are described as to their application for determining the effects of various processing steps, establishing the value of individual operations, and evaluating the significance of test results. The elimination of unnecessary or detrimental processing steps was accomplished and the number of required tests was substantially reduced by application of these statistical methods to the SNAP 10A production development effort. (auth)

**11315** (NAA-SR-7661) PERFORMANCE OF CESIUM THERMIONIC DIODES OPERATED IN SERIES-PARALLEL CIRCUITS. J. W. Holland (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Feb. 1, 1963. Contract AT-11-1-GEN-8. 38p.

Electrical power degradation from the operation of many series-parallel circuited cesium diodes in a thermionic reactor must be considered when a nonflattened nuclear power distribution exists over the volume of the reactor core. This experiment measures the loss of power and efficiency due to unequal heat inputs to series- or parallel-connected diodes, and studies the operating characteristics of a multiple-diode system. The results are applied to a specific thermionic reactor configuration with a ratio of maximum to minimum diode heat input of 1.85. The minimum degradation of power and efficiency was found to be 41 and 19%, respectively, at optimized operating conditions. (auth)

**11316** (NAA-SR-Memo-6741) HIGH TEMPERATURE SEEBECK COEFFICIENT APPARATUS. E. G. Forster, Jr., and A. J. Saur (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Sept. 14, 1961. Contract [AT-11-1-GEN-8]. 33p.

An apparatus for measuring the Seebeck Coefficient of pellets of "N" and "P" types of lead tellurides was built and operated. The apparatus will measure the Seebeck Coefficient as a function of temperature in the range extending from 350°F up to the melting point of lead telluride. With proper operating technique and applying corrections for known systematic errors, the probable error in the results is less than 20%. (auth)

**11317** (NP-12322) STUDY OF THE EDGE EMISSION OF CADMIUM SULPHIDE BOMBARDED BY ELECTRONS. Final Technical Report, Oct. 1, 1961–September 30, 1962. (Laboratorie d'Infra-rouge Technique et Applique, Gif-Sur-Yvette, France). Contract 62558-2720. 16p.

During 1961-62 the laboratory work was devoted mainly to the confirmation of results obtained in experiments at liquid air temperatures and to experiments with polarized light. Information is included concerning equipment developed during the period. Experimental results on the emission of CdS at 77 and 42°K are also included. (J.R.D.)

**11318** (NP-12357) SPUTTERING BY NORMALLY INCIDENT AND OBLIQUELY INCIDENT POSITIVE IONS (thesis). Alan Rex Cole (Air Force Inst. of Tech., Wright-Patterson AFB, Ohio). May 1962. 103p. (GNE/Phys/62-4)

An experimental study is described which involves the use of a low pressure plasma as a source of bombarding ions and a spectrometric method for measuring sputtering yield of positive ions. The investigation was conducted to determine the effect of the incidence angle of the bombarding ions upon the sputtering yield and upon the threshold energy for sputtering with the particular ion-target combination used. It was found that obliquely incident ions apparently contribute much more to the total sputtering yield, over all observed ranges of bombarding ion energies, than do normally incident ions. For the bombardment of Au with Ar ions, thresholds of ion energy for obliquely incident ions and for normally incident ions were found to be about 25 and 32 ev respectively. The investigation must be extended to more combinations of bombarding ions and sputtering targets before a definite contribution can be made to the theory of sputtering mechanism; however, it appears that the more efficient sputtering by obliquely incident ions must be taken into account over all ranges of ion energies. (auth)

**11319** (NP-12358) THE MULTIPLE-CROSSED-BEAM METHOD FOR MEASURING ELECTRON-IONIZATION CROSS SECTIONS. Technical Report 175. C. K. Crawford and C. E. Woodward (Massachusetts Inst. of Tech., Cambridge. Lab. for Insulation Research). Nov. 1962. Contracts AF33(616)-8353 and Nonr-1841(10). 37p.

A new method for measuring the absolute values of electron-ionization cross sections is proposed. The technique involves intersecting two electron beams with a single atomic beam composed of the material to be studied. Pulsing the first electron beam results in an atomic-beam modulation which may be detected by the second electron beam. Ionization cross sections may be determined if the resulting ion currents are measured and the intersection geometries known. The absolute material-flow rate may also be determined. If a mass spectrometer is provided, the technique may be used on atomic beams composed of several constituents. The absolute cross-section values and the flow rates may be calculated separately for each constituent. The pre-ionization mass and the source temperature can

also be calculated. The theory for the method was developed, and suitable experimental apparatus was built. The technique was demonstrated using Mg. In its present form the signal-to-noise ratio is poor, about 2:1, but suggestions are made which would improve it by more than two orders of magnitude. More work is required before useful cross-section data can be obtained. (auth)

**11320** (NP-12360) THE DISPLACEMENT OF THE SELENIUM ATOM IN SINGLE-CRYSTAL ZINC SELENIDE BY ELECTRON BOMBARDMENT (thesis). Robert Milan Detweiler (Air Force Inst. of Tech., Wright-Patterson AFB, Ohio). May 1962. 67p. (GNE/Phys/62-5)

The fluorescence structure and the displacement energy of lattice atoms in single-crystal synthetic zinc selenide were investigated with a low-energy electron beam probe. Fluorescence peak intensities at 77°K were observed at 0.45, 0.46, 0.49, 0.525, 0.55, 0.64, 0.85, 1.0, 1.25, 1.65, 2.0, and 2.2 $\mu$. The temperature dependence of 5 of the more prominent peaks was examined. The structured edge emission containing as many as 5 lines has also been observed. The threshold for the controlled growth of a broad 0.55 $\mu$ peak band was observed at 240 ± 10 kev, which corresponds to a maximum energy transfer to the Se atom of 8.2 ev. Although positive evidence is lacking, the causing defect for the 0.55 $\mu$ band appears to be the Se vacancy. (auth)

**11321** (NP-12418) DORMOUSE PRIME. Long Range Seismic Measurements [of] VELA UNIFORM Project 8.4. DATDC Report No. 22. (United ElectroDynamics, Inc., Alexandria, Va.). Apr. 5, 1962. Contract AF33(657)-7427. 30p.

Information and computation results derived from data obtained at long-range seismic measurement sites on Dormouse Prime detonation travel times, amplitudes, and magnitudes are presented. A list of LRSM sites is included containing information on coordinates, distance from the Nevada Test Site, elevation, type of site, and site instrumentation. (J.R.D.)

**11322** (NP-12429) DIRECT ENERGY CONVERSION LITERATURE ABSTRACTS. (Naval Research Lab., Washington, D. C.). Dec. 1962. 121p.

A collection of 735 references from various sources is presented covering the current literature on thermoelectricity, thermionic emission, photoelectric processes, magnetohydrodynamics, electrochemical processes, energy storage, and energy sources. (auth)

**11323** (NYO-9188) ON CERTAIN FINITE DIFFERENCE SCHEMES FOR THE EQUATIONS OF HYDRODYNAMICS. John Gary (New York Univ., New York. Atomic Energy Commission Computing and Applied Mathematics Center). Mar. 1, 1962. Contract [AT(30-1)-1480]. 23p.

The application of two finite difference schemes of second order accuracy to the equations of viscid and inviscid flow is examined. The first is the Lax-Wendroff scheme, the second an iterative scheme. A stability criterion is obtained for the iterative scheme by the method of von Neumann, and an empirical stability criterion is obtained for the Lax-Wendroff scheme as applied to viscid flow. The accuracy of these methods and their effectiveness for flows that contain a shock are also discussed. (auth)

**11324** (NYO-9603) NUMERICAL COMPUTATION OF HYDRODYNAMIC FLOWS WHICH CONTAIN A SHOCK. John Gary (New York Univ., New York. Atomic Energy Commission Computing and Applied Mathematics Center). Feb. 1, 1962. Contract [AT(30-1)-1480]. 17p.

Richtmyer's finite difference method for the computation of hydrodynamic flows that contain a shock is described. This method uses the Eulerian form of the hydrodynamic equations, is explicit, is of second order accuracy, and is based on shock fitting rather than the introduction of artificial viscosity. The result of numerical computations using a modification of this finite difference method is described, and the method is applied to a one-dimensional problem for which a solution can be computed by solving an ordinary differential equation. Therefore the accuracy of the method for this problem can be determined. (auth)

**11325** (PUC-1962-68) A NEW EXPERIMENTAL LIMIT ON THE VELOCITY DEPENDENT INTERACTION BETWEEN NATURAL CLOCKS AND DISTANT MATTER (thesis). Kenneth Clyde Turner (Princeton Univ., N. J. Palmer Physical Lab.). Apr. 1962. Contract AT(30-1)-937. 89p.

An experiment setting an upper limit on a frequency shift between two oscillators of the form $\Delta f/f = 2\,\vec{u}\cdot\Delta\vec{V}/C^2$, where $\Delta\vec{V}$ is the velocity of one oscillator relative to the other, and $\vec{u}$ is the velocity of the laboratory in that reference frame in which distant matter has an isotropic velocity distribution is reported. Such a frequency shift might be interpreted as exhibiting the effect of distant matter in determining the strengths of the interactions important to the oscillator involved. The experiment utilized the Mössbauer effect in iron-57. A source of cobalt-57 was placed on the rim, and an iron absorber near the center, of a centrifuge. By looking for position dependence of the resonance absorption of the 14.4 kev gamma ray, it was possible to determine that the velocity of the laboratory in the special frame defined above was less than 900 cm/sec. (auth)

**11326** (SC-4747(RR)) THREE LOW-PRESSURE SPALL THRESHOLDS IN COPPER. J. H. Smith (Sandia Corp., Albuquerque, N. Mex.). Jan. 1963. Contract [AT(29-1)-789]. 29p.

Measured values of the three low-pressure spall thresholds in copper plate are presented. The two lower thresholds are original with this program. However, the incipient spall threshold or beginning of tensile damage corresponds rather closely in magnitude to the dynamic elastic yield strength of copper in compression. The complete spall threshold corresponds to the value determined by Rinehart for copper. Thresholds are presented in terms of pressure and pulse-width, and the effect of varying the pulsewidth with a given pressure is shown. The experimental methods, including properties of the compressed-air gun, are discussed since they are applicable to most metals and many nonmetals. (auth)

**11327** (TID-15759) THE CORRELATION OF COLOR AND NON-STOICHIOMETRY. R. J. Thorn and G. H. Winslow (Argonne National Lab., Ill.). Mar. 1962. Contract [W-31-109-eng-38]. 23p. (UAC-6213)

The correlation of color and non-stoichiometry in materials that show gross departures from stoichiometry requires a study of the thermodynamics of non-stoichiometric phases and of the physics of light absorption by color centers. Numerical correlation is possible in several directions; in particular, each of the two theories can produce predictions of the density of "imperfections." $UO_2$ is used as an example; the study of its absorption spectrum immediately demonstrates the importance of at least two types of imperfection in the study of the $UO_{2+x}$ phase. (auth)

**11328** (TID-15769) THE ELASTIC SCATTERING OF POSITRONS BY ATOMIC HYDROGEN. W. J. Cody, Joan Lawson, H. S. W. Massey, and Kenneth Smith (Argonne

National Lab., Ill. and London. Univ. University Coll.). Mar. 19, 1962. Contract [W-31-109-eng-38]. 21p. (UAC-6253; KS-28)

Zero-order partial wave phase shifts for the scattering of positrons from the 1s state of atomic hydrogen are calculated. These calculations are performed in four approximations: A, 1s-2s-2p close-coupling approximation; B, in the static approximation including the induced dipole polarization potential, $\alpha/r^4$; C, in the strong-coupling approximation 1s-1s, that is, including the 1s states of atomic hydrogen and positronium; and D, including $\alpha/r^4$ in 1s-1s. The principal result is that the overall attraction between positron and hydrogen atom is obtained in those approximations that include $\alpha/r^4$. Wave phase shifts calculated by different methods are listed. (auth)

**11329** (TID-15934) THE MAGNETIC CHARACTERISTICS OF GADOLINIUM, TERBIUM AND YTTERBIUM HYDRIDES IN RELATION TO THE ELECTRONIC NATURE OF THE LANTHANIDE HYDRIDES. W. E. Wallace, Y. Kubota, and R. L. Zanowick (Pittsburgh. Univ.). [1962]. Contract AT(30-1)-647. 18p.

Hydrogenation of the heavy lanthanides leads to the formation of cubic dihydrides and hexagonal trihydrides, each of which exists over a considerable range of composition. Metallic conduction is exhibited by the dihydrides but not by the trihydrides suggesting that the latter lack conduction electrons. As exchange between the higher localized 4f electrons occurs via the conduction electrons, the magnetic ordering which occurs in the lanthanides requires a substantial population of electrons in the conduction band. The lanthanide trihydrides give no indication of magnetic ordering at low temperatures indicating that they lack conduction electrons. Since the atomic moment is essentially unchanged by hydrogenation the number of core electrons is unchanged in the process. From this one concludes that the conduction electrons are absorbed by the dissolving hydrogen to form the $H^-$ ion and hence the trihydrides are essentially ionic in nature. The dihydrides exhibit metallic conduction and also order at low temperatures. The temperature at which alignment sets in is, however, considerably lower than that for the corresponding metal. This behavior suggests that the dihydrides are similar electronically to the trihydrides except that in the former the conduction band is not completely depopulated and hence the bonding in these hydrides represents an intermediate stage between the metals on the one hand and the truly ionic trihydrides on the other. (auth)

**11330** (TID-16045) THE DETERMINATION OF ACCURATE LATTICE PARAMETERS IN TETRAGONAL METALS AND ALLOYS. H. W. King and T. B. Massalski (Mellon Inst., Pittsburgh). [June 1962]. Contract [AT (30-1)-2684]. 6p.

A graphical extrapolation method is given for determining accurate lattice parameters of tetragonal structures from x-ray diffraction data. The use of the method is illustrated for beta tin. (D.L.C.)

**11331** (TID-17023) REPORT OF RESEARCH IN HIGH-ENERGY NUCLEAR PHYSICS, NOVEMBER 1, 1961–OCTOBER 31, 1962. (Carnegie Inst. of Tech., Saxonburg, Penna. Nuclear Research Center). Contract AT(30-1)-882. 33p.

Status reports are given for research on the reaction rate for $\mu^- + He^3 \rightarrow H^3 + \nu$, on liquid helium scintillation counters, on solid state radiation detectors, on proton spallation in light elements, on $\mu^-$ lifetimes, on spark chamber investigation of Dalitz pairs from $\pi^0$ decay, on $\pi^-$ - p interactions at 560 and 650 Mev, on radiative capture of $\mu$ mesons by nuclei, on the search for the reaction $\pi^+ \rightarrow \pi^0 + e^+ + \nu$, on spark chamber investigations, on $\mu^-$ capture in heavy elements, on bubble chamber operation and development, on interactions of 141-Mev $\pi^-$ mesons with deuterium, on $\pi^-$ - n total cross section at 136 Mev, on $\pi^-$ stops in hydrogen–deuterium and hydrogen–helium mixtures, on $\mu^-$ absorption in carbon in a propane bubble chamber, on $\mu^-$ stops in carbon, aluminum, copper, and lead, on strange particle production in $\pi^-$-p interactions, on antiproton interactions in deuterium, on beam stretching and improvement, on an external proton beam, on an auxiliary meson beam, on $\mu^-$ capture, on weak interaction theory, on hyperon decay, on N-$\bar{N}$ annihilation, on polarization effects in high-energy scattering, on dispersion relations, on dynamical models in strong interaction physics, on theory of strong interactions, on nonradiative E2 transitions in $\mu$ mesic atoms, on convergence of the Born approximation for non-central forces, on Auger rates of $\pi^-$ atoms, on $K_1^0$-$K_2^0$ mass differences, on a slide rule for complex numbers, on scattering of charged spinless particles, on $K^-$-N scattering, on solution of integral equations, on $\mu$ spin (found to be $\frac{1}{2}$), on lepton conservation laws and the existence of two neutrinos, on electromagnetic structure of nucleons, and on meson trajectories in the cyclotron field. Lack of success in finding a new $\pi$-N resonant system in p-p interactions and some evidence for the existence of $\xi^+$ is noted. A redetermination of $\mu^-$ capture in lithium isotopes and in oxygen is to be made due to the extremely high rate obtained. An expression for the speed of $\gamma$ rays from a moving source is also given. Twenty-six papers published during the period are listed. (D.C.W.)

**11332** (TID-17590) YALE UNIVERSITY NUCLEAR RESEARCHES, PROGRESS REPORT, FEBRUARY 1, 1961 TO JANUARY 31, 1962. (Yale Univ., New Haven). Contract AT(30-1)-2726. 99p.

Research in high-energy particle physics is reported. Included are summaries of work done with the AGS and the Cambridge accelerator. Other work is reported on design of a high-intensity proton linear accelerator for energies up to 1 Bev. Research in low-energy nuclear physics is also reported concerning inelastic scattering, Coulomb excitation, single-nucleon transfer reactions, cluster studies, high angular momentum effects, nuclear reactions, statistical models, fission, lifetime measurements, and beta decay. Other work is reported on instrumentation development, accelerator operations, development of polarized beams, and targets and isotope separation. (J.R.D.)

**11333** (TID-17640) A PROPOSED SYSTEM TO OBTAIN HIGHER SPACE RESOLUTION IN NUCLEAR EMULSIONS. J. H. Roberts, P. C. Chow (Northwestern Univ., Evanston, Ill.); and G. R. Ringo (Argonne National Lab., Ill.). Oct. 1962. Contract [W-31-109-eng-38]. 20p. (UAC-6998)

One of the principal advantages of nuclear emulsions over bubble chambers, cloud chambers, and spark chambers is high space resolution. For certain applications it seems wise to push this advantage as far as possible through the use of finer grain emulsions and higher magnification. A method of achieving the latter by use of a high-energy (~300 kev) electron microscope is proposed. Electron photomicrographs of grains in particle tracks showing distributions in grain diameters and variations in grain structure for various nuclear emulsions processed by different developers are given. Tests of a method of preparing stacks of thin emulsion are discussed. Applications of the technique to hyperfragment studies, to neutron spectroscopy, to the study of short lived particles, and to

other problems in nuclear and particle physics are considered. The needs for finer grain emulsions with high sensitivity and tests of TEA hypersensitization are presented. (auth)

**11334** (TID-17677) NOTES ON THE THEORY OF A COAXIAL SHUNT. G. Cinelli (Argonne National Lab., Ill.). Oct. 1, 1962. Contract [W-31-109-eng-38]. 31p.

Accuracy of resistance determinations limits the precision of voltage measurements of a coaxial shunt. Therefore, a theoretical study to develop formulas that indicate the change in magnitude of resistance caused by forces such as temperature and stress is undertaken. Coaxial shunt current equations are derived from Maxwell's field equations, and the effective four-terminal impedance of a coaxial shunt with the potential leads on the outside is found. Magnetic forces on the outer tube due to the shunt current are calculated, and solutions of coaxial shunt equations for an arbitrary current are given. Eddy current heating, particularly power loss for sinusoidal currents, is also discussed. (D.C.W.)

**11335** (TID-17827) EXPERIMENTS WITH SUPERCONDUCTING WIRE AND SOLENOIDS. C. Laverick and H. K. Ihrig (Argonne National Lab., Ill.). Oct. 30, 1962. Contract [W-31-109-eng-38]. 13p.

Experimental runs were made to study the performance of Westinghouse and Wah Chang wire coils in zero fields and in solenoid fields. Faults were found in the superconducting-to-normal joints. (D.L.C.)

**11336** (UCRL-6820) THE EFFECT OF BAND STRUCTURE ON THERMIONIC EMISSION. W. E. Spicer (California. Univ., Livermore. Lawrence Radiation Lab.). Mar. 13, 1962. Contract W-7405-eng-48. 21p.

The problem of thermionic emission from a solid was treated theoretically for any general band structure without assuming the Drude-Sommerfeld free electron model. It is shown that only the bands which have a finite density of states near the vacuum affect the emission. For these bands, it is the areal density of states in the plane perpendicular to the direction of emission near the band minima which are of importance. Specifically, the rate of arrival of electrons with sufficient energy to escape over the surface barrier is $J_c = eD_c \exp(-e\phi_c/kT)$ where $D_c$ is a function of the band structure near the band minima in the plane perpendicular to the direction of emission and of the temperature. For emission into a vacuum, the maximum value of the current density is $AT^2 \exp(-e\phi_c/kT)$ where $A = 120$ amp/cm$^2$(°K)$^2$; however, A may have any value less than 120, depending on the band structure of the solid. In the latter case, there will be a reflectivity of magnitude $(1 - A/120)$ due to the density of states in the solid for external electrons incident on the solid with thermal energies. (auth)

**11337** (UCRL-7146) METHOD FOR CALCULATING THE AMPLITUDE OF THE REFRACTION ARRIVAL. Glenn C. Werth (California. Univ., Livermore. Lawrence Radiation Lab.). Nov. 28, 1962. Contract W-7405-eng-48. 32p.

A method based on Zvolinskii's "near-front" approximation is given for calculating amplitudes of refraction arrivals. The theory was checked to a limited extent with measured amplitudes of seismic waves from nuclear explosions, and agreement was good. To illustrate a possible use of the method in refraction prospecting for oil, calculations were made for a model geologic section based on well data from the Edwards Plateau in West Texas. The calculations show that layering above a refractor can materially change the character of the refraction arrival. It is shown how this character change may be useful as an indicator of structure in the refractor. (auth)

**11338** (UCRL-13059) PROBLEMS IN THERMOVISCOELASTICITY. R. L. Taylor (California. Univ., Berkeley. Inst. of Engineering Research). Jan. 1963. For Univ. of California, Lawrence Radiation Lab., Livermore. Contract [W-7405-eng-48]. 91p.

The displacement equations of equilibrium governing the behavior of stressed, isotropic, thermorheologically simple materials subjected to thermal variations are formulated with respect to integral constitutive equations. This leads to a system of three, second order, variable coefficient, partial differential equations in the spatial coordinates and an integral equation in the time. The alternate formulation in terms of stresses or stress functions is discussed; however, it is conjectured that, in general, the stress formulation leads to a more complex system of equations to be solved. An exception to this fact is discussed in connection with axisymmetric plane stress. The general problem is formulated within the framework of classical, uncoupled thermoviscoelastic theory. A solution to the general displacement equations of equilibrium is presented for a point symmetric temperature field and point symmetric boundary conditions. Numerical results are presented for the uniform heating or cooling of a composite elastic-viscoelastic hollow sphere. Problems in axisymmetric plane strain and axisymmetric generalized plane stress are also considered. Due to the form of the equations, the general integrals for axisymmetric problems subjected to varying temperatures are not recoverable by standard techniques (except for an incompressible material); hence, only uniformly varying temperatures are considered. Numerical results are presented for the plane strain problem. The general theory is also formulated from the principle of virtual displacements. From the principle of virtual displacements, it is shown how exact, as well as approximate, solutions may be obtained. Examples are included for the exact solution to an incompressible hollow cylinder, the extension of a thermally induced nonhomogeneous bar, and uniform temperature change in a composite elastic-viscoelastic bar. (auth)

**11339** (WIS-AEC-34) GENERALIZED MOMENTUM OPERATORS IN QUANTUM MECHANICS. Series 3. Peter D. Robinson and Joseph O. Hirschfelder (Wisconsin. Univ., Madison. Theoretical Chemistry Lab.). Apr. 16, 1962. Contract AT(11-1)-298. 14p.

The usual form for the quantum-mechanical operator P conjugate to a generalized coordinate q is noted to be non-Hermitian with respect to physically acceptable bound state wave functions in some cases. A corrected form is shown to be always Hermitian with respect to acceptable bound state wave functions. Eigenfunctions for the new form are not necessarily orthogonal as with the usual form. (D.C.W.)

**11340** (AEC-tr-5615) ION-ATOM INTERACTION IN GAS. L. A. Sena. Translated for Oak Ridge National Lab., Tenn. from Zh. Eksperim. i Teor. Fiz., 9: 1320-31(1939). 17p.

Measurements are given of the effective scattering and overcharge cross sections of ions and of their dependence on the properties of the gas, the velocity of ions, and the geometry of the apparatus. The results are compared with the data of Rostagni, Wolf, and other authors. (auth)

**11341** THE EFFECT OF POLARIZATION ON THE RETARDATION OF NON-RELATIVISTIC CHARGED PARTICLES. Gunnar Aniansson (Royal Inst. of Tech., Stock-

holm). Acta Chem. Scand., 16: 2087-99(1962). (In English)

The theory for the effect of dielectric polarization on the retardation of non-relativistic charged particles was re-examined. An expression for the effect was obtained in which the dominant term is similar to that obtained by Fermi. It differs by a multiplicative factor and an additive term, both dependent on a parameter describing the form of the oscillator strength distribution. The influence of the local field correction for the dielectric constant of the medium was also taken into account. (auth)

**11342** OBSERVATION OF PROTON MAGNETIC RESONANCE SHIFTS IN $H_2O-D_2O$ MIXTURES. Mats S. Bergqvist and L. E. Goeran Eriksson (Royal Inst. of Tech., Stockholm). Acta Chem. Scand., 16: 2308-10(1962). (In English)

A proton magnetic resonance study was made of $H_2O-D_2O$ mixtures. PMR shifts were determined at 60 mC/sec both by internal and external reference methods. However, the reference methods do not coincide. The PMR shift in the mixture appears to be a linear function of the deuterium concentration. The results indicate a PMR shift for a proton in $D_2O$ relative to that in $H_2O$ of about 0.02 ppm (average between internal and external reference methods). (P.C.H.)

**11343** THE QUANTUM STATISTICS OF MOLECULES WITH INTERNAL ROTATION: WIGNER SERIES DEVELOPMENT FOR PARTIAL FUNCTION AND THERMODYNAMIC FUNCTIONS OF SYMMETRICAL ROTATOR. Guenter Vojta (Karl-Marx-Universität, Leipzig). Ann. Physik (7), 9: 337-50(1962). (In German)

An inhibited symmetrical rotator in a multiatomic molecule was investigated as an example for an almost classical system using the series development of Wigner up to the term $h^4$. A simple closed formula for the partial function and therefore for the thermodynamic functions F, U, S, and C of the rotators was obtained. In it the Bessel functions $J_0$ and $J_1$ of the purely imaginary arguments $ix = iV_0/2kT$ ($V_0$ is the height of the inhibition potential) occur. The zero point energy was determined by perturbation calculation up to the third order for a strongly inharmonic torsion oscillator. Therefore it is possible to eliminate the contribution of the zero point energy to the partial function and the thermodynamic function. The formulas obtained are of great accuracy from most generally occurring symmetrical rotators, as a comparison with the tables of Pitzer et al. show. (tr-auth)

**11344** EXCHANGE INTERGRALS BETWEEN FUNCTIONS OF K OR L AND O SHELLS FOR EQUALLY EFFECTIVE NUCLEAR CHARGES. G. Klose (Karl-Marx-Universität, Leipzig). Ann. Physik (7), 9: 351-66(1962). (In German)

A series of exchange intergrals between functions of the K or L and O shells for equally effective nuclear charges was calculated by the Sugiura method. The formulas were given, and the intergrals were tabulated in a value range $\alpha = 4.0\ (0.5)\ 7.0$ and for 8.25 and 8.75. (tr-auth)

**11345** THE PHYSICAL SIGNIFICANCE AND REPRESENTATION THEORY ANALYSIS OF CONFORMAL TRANSFORMATIONS OF SPACE AND TIME. H. A. Kastrup (Universität, Munich). Ann. Physik (7), 9: 388-428(1962). (In German)

A study was made to interpret the scalar transformations and special conformal transformations of time and space as position-independent and position-dependent degaging of the length units. It is therefore shown that the assignment of length dimensions to physical magnitudes is synonymous with the requirement that these pertain to a representation of the scalar transformation. A representation theory analysis using the Cartan method shows that whole numbers always belong to tensors as length dimension. All representations of finite degrees of the 15-parameter conformal group can be constructed by means of two four-dimensional spin representation in which one uses the well-known properties of Dirac algebra, which can be interpretated as the Lie algebra of conformal transformation. Therefore one has such combinations of the $\gamma$ matrices as occur in the theory of weak interaction (V-A coupling). If the Lie algebra of the conformal group is represented within the framework of functions with coordinates $x^\mu$, it becomes impossible to represent a positively defined metrics and the eigenfactors of the energy pulse operators form no complete system. It appears that the physically interesting representation of infinite degrees of the conformal group are not unitary. A relation between the four operators that produce the infinitesimal special conformal transformation and the quantum mechanical place operators exist. In conclusion it was shown that the known fields belonging to the inhomogeneous Lorentz group form only an incomplete representation of the conformal group as a result of nonsymmetry in the length dimensions. (tr-auth)

**11346** THERMIONIC EMISSION CHARACTERISTICS OF RHENIUM WITH LOW CESIUM COVERAGE. John G. DeSteese (Westinghouse Research Labs., Pittsburgh). Appl. Phys. Letters, 2: 25-7(Jan. 15, 1963).

The method uses the test material in the form of a small wire loop emitter passing through insulating ceramic sleeves that expose a short length of the loop to a cesium vapor plasma. The emitter was held slightly negative with respect to the plasma to neutralize the emission-retarding effects of the electron space charge at the emitter. S-curve data for rhenium were presented at cesium pressures in the range $10^{-4}$ to $10^{-2}$ Torr. The emitter was heated with half-wave rectified a-c current. For values of the work function ($\phi$) less than 3.2 ev, emission currents were found to depend only slightly on the positive ion current drawn to the emitter. For regions of low coverage ($\phi > 3.2$ ev), the emission was found to switch randomly between two principal modes for several seconds after reaching each temperature setting. At the end of this period the emission current persisted in the mode of higher density. The ratio of high to low mode current was found to increase with cesium pressure. The double mode effect could not be initiated by any change of emitter potential or plasma discharge current in regions of higher coverage and similar or larger emission densities. (C.E.S.)

**11347** ELECTRON AND ION EMISSION FROM CESIUM-COATED REFRACTORY METALS IN ELECTRIC FIELDS. R. J. Zollweg (Westinghouse Research Labs., Pittsburgh). Appl. Phys. Letters, 2: 27-9(Jan. 15, 1963).

At low cesium coverage a surface phenomenon with a discontinuous change of coverage and of electron and ion emission may take place even for uniform work-function emitters in accordance with the Saha-Langmuir equation. These phenomena may have a bearing on the relative emission rates of electrons and positive ions. The Saha-Langmuir equation gives a relation between Cs atom and ion evaporation rates, $\ln(2\nu_p) = \ln \nu_a + (e/kT)(\phi - I)$, where $\nu_p, \nu_a$ = evaporation rates of ions and atoms respectively, $\phi$ = work function of the emitter with equilibrium Cs coverage, and I = ionization potential of the vapor. At equilibrium coverage the atom arrival rate must equal the sum of the atom and ion evaporation rates. When an electric field opposing ion emission was applied, the ion

evaporation rate $\nu_p$ was drastically reduced while the atom evaporation rate was relatively unchanged. With a relatively weak electric field opposing ion emission, ions would continue to evaporate but would be confined to a certain region near the emitter by a sort of semipermeable membrane, permeable to atoms but not ions. The surface electric fields referred to will usually be caused largely by sheaths, but these in turn will depend upon external electrode potentials since the latter play a significant role in the removal rate of charge carriers. (C.E.S.)

**11348** THE CHANNELING OF ENERGETIC ATOMS IN CRYSTAL LATTICES. Mark T. Robinson and O. S. Oen (Oak Ridge National Lab., Tenn.). Appl. Phys. Letters, 2: 30-2(Jan. 15, 1963).

Preliminary studies showed that ~1% of 10-kev Cu atoms, starting from lattice sites and slowing down according to the Bohr potential, made very long flights, predominantly in (110) directions. These channeled particles did not move in force-free regions but experienced very many glancing collisions with atoms of the lattice, which steered them into (110) directions. This phenomenon of channeling so dominates the Bohr potential calculations for particles normally incident upon the low index planes of Cu that no reliable statistical inferences about range distributions can be drawn. The probability of channeling increases rapidly with increasing energy for particles incident upon (110) and (100) from energies below 1 kev and for particles incident upon (111) from about 3 kev. In each case, the preferred channel is normal to the crystal surface. In the isotropic case, the probability of channeling remains roughly constant at about 1% between 1 and 10 kev, the (110) channels being strongly preferred. Channeling is not restricted to fcc crystals. Calculations for diamond and bcc structures also show extensive channeling. The existence of channeling may have significant implications for radiation damage theory, since the channeled particles lose their energy in very small increments, thus producing far fewer displacements than would be expected on the basis of conventional cascade theory. (C.E.S.)

**11349** CURRENT-CARRYING CAPACITY OF HIGH FIELD SUPERCONDUCTING SOLENOIDS. B. S. Chandrasekhar and J. K. Hulm (Westinghouse Research Labs., Pittsburgh). Appl. Phys. Letters, 2: 43-4(Jan. 15, 1963).

A functional relation between the diamagnetically induced current $I_d$ in amperes and the field H in gauss produced by a high field solenoid was given by $I_d = K \cdot G(H) \cdot H$, assuming that G(H) varied monotonically from unity at low fields to zero at high fields, reflecting the shape of the magnetization curve for a hard superconductor. K is a constant determined by the requirement that at very low fields flux is completely excluded from the wire. The field distribution in the solenoid windings was assumed to be uniform. Any influence of the shape and size of the solenoid is neglected apart from that implied in $H = \phi \cdot I$, where I is the solenoid current. The maximum coil current $I_m$ was determined by $I_m = I_c - I_d$, where $I_c$ is the critical current of an isolated wire in a corresponding transverse field. The equations produced the relation $I_m = I_c/1 + K \cdot \phi \cdot G(H_m)$. This model was highly simplified but the results should have qualitative significance. (C.E.S.)

**11350** THE MULTIPOLE EXPANSION IN QUANTUM THEORY. J. Fiutak (Univ. of Toronto). Can. J. Phys., 41: 12-20(Jan. 1963).

The hamiltonian of a system of charged particles interacting with the electromagnetic field is investigated. For an arbitrary system the multipole expansion of the interaction between the system and the field is derived by means of a suitable canonical transformation. The transformed hamiltonian is obtained from the hamiltonian of the system by replacing the momenta by the transformed kinetic momenta and by adding to the hamiltonian a term representing the interaction of the system with the electric component of the field. By expanding this interaction term, as well as the transformed momenta, in powers of the dimension of the system over the wavelength, the multipole expansion of the hamiltonian is obtained. For a system interacting with a classical field the multipole form of the hamiltonian is exactly equivalent to the original hamiltonian. For a quantized field this is not true, and the multipole form of the transformed hamiltonian is shown to be equivalent to the original hamiltonian only for first-order radiation processes. (auth)

**11351** SPACE TIME IN THE HUND GRAVITATIONAL THEORY. Ll. G. Chambers (University Coll. of North Wales, Bangor). Can. J. Phys., 41: 46-9(Jan. 1963).

The metric associated by Hund with his gravitational theory is seen to disagree with one dictated by other considerations. An invariant metric form is derived, and a special case utilizing the ideal metric is examined. (D.C.W.)

**11352** LAMINAR JET OUTFLOW OF A CONDUCTING GAS INTO THE SPACE WITH A MAGNETIC FIELD. K. I. Strakhovich and Y. A. Sokovishin. Inzh.-Fiz. Zh., Akad. Nauk Belorussk. SSR, 5: No. 10, 65-9(Oct. 1962). (In Russian)

It is shown that the solution for a set of equations satisfying all the equations of magnetofluid dynamics cannot satisfy the magnetic part of the corresponding system. Moreover, with the assumption of only one transversal component of the magnetic field, the main values, being solved exactly, depend on the coordinate $\underline{x}$ alone, and this contradicts the initial conditions. Methods are proposed that allow velocity distributions and the components of the magnetic field to be calculated. (auth)

**11353** SIZING OF TARGETS OF RADIOACTIVE X-RAY SOURCES. D. Mueller and G. Brunner (Institut für Angewandte Radioaktivität, Lepzig). Isotopen Tech., 2: 257-61 (Sept. 1962). (In German)

Experimental investigation on the dependence of the intensity of K radiation excited by $\beta$ particles on the thickness of targets were described. Numerical consideration on the fluorescent excitation of characteristic radiation and on the production of K radiation leads to a formal expression that permit the determination of the optimum thickness of transmission targets. (tr-auth)

**11354** CONFORMAL COORDINATES ASSOCIATED WITH SPACE-LIKE MOTIONS. Robert T. Jones (Ames Research Center, Moffett Field, Calif.). J. Franklin Inst., 275: 1-12(Jan. 1963).

Conformal transformations in two dimensions provide a simple extension of the Lorentz transformation. The velocity of light appears in such transformations as a singular velocity rather than as an upper limit for the velocity. A well-ordered branch of the theory exists for velocities in excess of the velocity of light. If the velocity of a point exceeds the singular velocity in an inertial system, then the conformal representation of the motion is no longer uniform, but contains a folded region. However, the branching of the transformation may be determined so that the elapsed time along the path of such a motion remains positive. Kinematic relations on the other side of the singular velocity seem to complement the usual results of relativity theory in an interesting way. Thus it is known that motion at the speed of light occurs along a null geo-

desic, and hence corresponds in a certain sense to motion at infinite velocity (that is, in the sense of proper time elapsed). The complementary relation is that a motion of infinite velocity corresponds in the same sense to motion at the speed of light. (auth)

**11355** AXI-SYMMETRIC MAGNETIC FIELDS AND RELATED PROBLEMS. Vivian O'Brien (Johns Hopkins Univ., Silver Spring, Md.). J. Franklin Inst., 275: 24-35 (Jan. 1963).

The current flux function defined by Stokes for incompressible (solenoidal) velocity vector fields is generalized to other axi-symmetric field problems. A table useful for many physical problems is presented along with some examples of magnetic field problems solved by use of the magnetic flux function. This function gives the magnetic lines of force in the field directly. (auth)

**11356** CARBON-13 SPLITTINGS IN FLUORINE NUCLEAR MAGNETIC RESONANCE SPECTRA. Norbert Muller and Duane T. Carr (Purdue Univ., Lafayette, Ind.). J. Phys. Chem., 67: 112-15(Jan. 22, 1963).

Spin-spin coupling constants between $F^{19}$ and directly bonded $C^{13}$ nuclei were measured for a wide variety of organofluorine compounds. The coupling constants tend to decrease with increasing fluorine chemical shifts. It is suggested that the degree of C–F double bond character is the most important single parameter influencing both of the observed quantities, with increased double bonding leading to stronger C–F coupling and decreased fluorine magnetic shielding. Increasing $C^{+}-F^{-}$ ionic character apparently entails increased fluorine shielding and reduced C–F coupling, but this effect is quantitatively less important. Increasing the s-character of the carbon orbital used in the C–F bond also appeared to reduce the magnitude of the C–F coupling constant. A number of long-range C–F, H–F, and F–F coupling constants also are reported. (auth)

**11357** ON THE USE OF GREEN FUNCTIONS IN PERTURBATION THEORY. [PART] I. D. ter Haar. Kgl. Norske Videnskab. Selskabs, Forh., 34: 77-80(1961). (In English)

It is shown that a technique using the double-time Green's functions leads to the perturbation expansion for a discrete energy eigenvalue for a many-body system. (T.F.H.)

**11358** ON THE USE OF GREEN FUNCTIONS IN PERTURBATION THEORY. [PART] II. D. ter Haar and H. Wergeland. Kgl. Norske Videnskab. Selskabs, Forh., 34: 81-5(1961). (In English)

A Green's function method is used to calculate the natural line width of a spectral line of a many-body system. The result is shown to be identical to the result obtained by time-dependent perturbation theory. (T.F.H.)

**11359** CALCULATION OF THE DISTORTION OF THE INCIDENT s-WAVE IN THE IONIZATION OF THE HYDROGEN ATOM BY ELECTRONS. V. Ya. Veldre and R. K. Peterkop. Opt. Spectry. (USSR) (English Transl.), 13: 257-8(Oct. 1962).

The S-cross section for the ionization of the hydrogen atom by electrons was calculated with the aid of an accurate (within the framework of the distorted waves method, ignoring polarization and strong coupling) elastic scattering function, which is found by numerical integration. The wave function of the final state is chosen in the Born-Oppenheimer (B-O) approximation. As a check on accuracy, the calculations were conducted at several energies with half-sized integration intervals; the results were practically unchanged. The phases of the elastic scattering were also computed and were in good agreement with previous results. Both cross sections ($Q_1$ and $Q_2$) were computed. The integration interval with respect to $\epsilon$ was varied from E/16 to E/32. The results indicate the importance of calculating the distortion of the incident s-wave when the incident electrons have low velocities. (P.C.H.)

**11360** THE PIEZOSPECTROSCOPIC EFFECT IN LITHIUM FLUORIDE CRYSTALS ACTIVATED BY HEXAVALENT URANIUM. A. A. Kaplyanskii and N. A. Moskvin. Opt. Spectry. (USSR) (English Transl.), 13: 303-7(Oct. 1962).

A reversible anisotropic polarized splitting of lines was observed in the spectra of LiF single crystals containing hexavalent U when the crystals were compressed along axes of various orders of symmetry. The splitting pattern points to the existence of anisotropic luminescence centers, oriented along 4-fold symmetry axes. Conclusions are drawn concerning several properties of the centers, including the multipolarity of the optical transitions. The nature of luminescence centers in LiF–U is discussed. (auth)

**11361** STRONG BOND AND EXCHANGE TAKEN INTO ACCOUNT IN THE COLLISIONS OF ELECTRONS WITH HYDROGEN ATOMS. R. Ya. Damburg and R. K. Peterkop. Opt. Spectry. (USSR) (English Transl.), 13: 338-9 (Oct. 1962).

Collision cross sections are calculated with the total orbital angular momentum L = 0 and with exchange and the bonds between the 1s, 2s, and 2p levels taken into account. When exchange is taken into account, taking the strong bond into consideration increases $\sigma_{1s\text{-}2p}$ close to the threshold and decreases with high energies; $\sigma_{1s\text{-}2p}$ is increased over the entire interval of energies. Taking exchange into account decreases both cross sections considerably as compared with calculations without exchange. Exchange and interference cross sections are practically equal for excitations. Direct, exchange, interference, and averaged couplings for L = 0 are tabulated. (P.C.H.)

**11362** A MECHANISM OF FIELD QUENCHING IN ZINC SULPHIDE PHOSPHORS. K. N. R. Taylor (Univ. of Durham, Eng.). Phys. Chem. Solids, 23: 1689-96(Dec. 1962).

A model is proposed to explain the experimental observations on the quenching of alpha-particle scintillations in zinc sulfide crystals by the application of an electric field. The existence of two kinds of center in the forbidden gap is assumed, one associated with the ground state of a luminescence center and the other with a non-radiative center. The necessity for such centers and the time sequence of events in the crystal is considered. Agreement with experiment is obtained and the height of the ground state of the luminescence center above the valence band is found to be 0.35 ev. The extention of this model to bombardment conductivity and electroluminescence in these crystals is also considered. (auth)

**11363** COMMENTS ON SUPERCONDUCTING PHASES IN THE Mo–Tc SYSTEM. J. B. Darby, Jr. and S. T. Zegler (Argone National Lab., Ill.). Phys. Chem. Solids, 23: 1825-7(Dec. 1962). (ANL-FGF-349)

X-ray diffraction analyses are made of the phase properties and lattice constants of Mo-(25 to 86 at.%) Tc alloys. The superconducting transition temperature is measured as 13.4°K for an as-cast alloy containing 60 at.% Tc, which has a single-phase $Cr_3O$-type structure. The mechanical workability of the alloys is discussed. (T.F.H.)

**11364** PRESSURE ANALYSIS OF CONDUCTION IN LIQUIDS. Otmar M. Stuetzer (General Mills, Inc., Minneapolis). Phys. Fluids, 6: 190-4(Feb. 1963).

Manometric measurements of the electrohydrostatic pressure distribution in dielectric liquids permit determination of space charge and field distribution, and of carrier generation rate. (auth)

**11365** CONCEPT OF FIELD MODES AND THE BEHAVIOR OF THE MAGNETOHYDRODYNAMIC FIELD. Francis H. Clauser (Johns Hopkins Univ., Baltimore). Phys. Fluids, 6: 231-53(Feb. 1963).

A method of studying the behavior of fields by splitting their behavior into independent field modes is presented. The method is used to explore the characteristics of steady, two-dimensional, linearized magnetohydrodynamic fields with finite viscosity and resistivity and arbitrary orientation of the magnetic vector relative to the velocity vector. It is shown that in general, boundary layers and wakes cease to exist in magnetohydrodynamics. Their place is taken by diffusing waves which, in reality, are the fields of a set of viscous–resistive sources, vortices, poles, and currents whose field lines are strongly oriented along the characteristic wave directions. When the viscosity and resistivity are equal, these waves diffuse in a simple and independent way, but when these quantities are not equal, the diffusing waves generate a new kind of wake which is located, veil-like, in the fan-shaped region between the two wave directions. These wakes are red from the differential diffusion of the primary waves. In the special case for which the resistivity is much greater than the viscosity, a new type of pseudo boundary layer is shown to exist in the velocity field. When the viscosity is much greater than the resistivity, this pseudo boundary layer occurs in the magnetic field. (auth)

**11366** EXCITATION AND POLARIZATION OF BALMER-$\alpha$ RADIATION IN ELECTRON-HYDROGEN ATOM COLLISIONS. H. Kleinpoppen, H. Krueger, and R. Ulmer (Universität, Tübingen, Ger.). Phys. Letters, 2: 78-9 (Aug. 15, 1962). (In English)

The relative cross sections and the polarization of the Balmer-$\alpha$ radiation in electron-hydrogen atom collisions were measured as a function of electron energy. The measured polarization fractions and relative differential cross sections of the Balmer-$\alpha$ line are plotted and used to calculate the relative total cross sections. (H.D.R.)

**11367** SCATTERING OF CONDUCTION ELECTRONS BY LOCALIZED MOMENTS IN METALS. A. R. Mackintosh and F. A. Smidt, Jr. (Ames Lab., Ames, Iowa). Phys. Letters, 2: 107-8(Aug. 15, 1962). (IS-463) (In English)

The scattering of conduction electrons from localized ionic moments in metals was studied by observing the change in residual resistivity of samples of pure lutetium, into which were dissolved small amounts of magnetic rare-earth metals. The results indicate that the exchange scattering of the conduction electrons is proportional to the factor $(g-1)^2J(J+1)$, where J is the localized ionic moment of the solute and g is the Landé factor. The magnitude of the exchange scattering is comparable with that caused by the change in the electrostatic lattice potential, due to the impurity ion. (H.D.R.)

**11368** EXCITATION OF OPTICAL FLUORESCENCE SPECTRA OF TRANSITION ELEMENTS BY MEANS OF X-RAYS. J. Makovskii, W. Low, and S. Yatsiv (Hebrew Univ., Jerusalem). Phys. Letters, 2: 186-7(Sept. 15, 1962). (In English)

X rays were used to investigating the properties of fluorescent materials, in particular of rare earth ions in an insulating matrix. A number of crystals containing rare earth ions in low concentration were irradiated with x rays, and all crystals showed a wealth of fluorescence lines. A general discussion of the spectra is given, and the possibilities and advantages of x-ray excitation are summarized. (H.D.R.)

**11369** FLUX TRAPPING. J. Jurisson and R. J. Oakes (Minneapolis-Honeywell Regulator Co.). Phys. Letters, 2: 187-8(Sept. 15, 1962). (In English)

A simple qualitative interpretation of the temperature dependence of flux trapping in superconductors is suggested. A model is described that embraces the main features of flux trapping characteristics of various superconductors studied by others. The temperature variation of the percentage flux trapping in tin as predicted by the model and the phenomenological expressions for penetration depth and coherence length are shown and discussed. (H.D.R.)

**11370** SUPERCONDUCTIVITY OF TRANSITION ELEMENTS. J. Peretti (European Atomic Energy Community, Ispra, Italy). Phys. Letters, 2: 275-6(Oct. 15, 1962). (In English)

Garland (Proc. VIIIth Int. Conf. on Low Temperature Physics, London, 1962) has suggested that the Coulomb interaction between the s electrons is screened in transition metals by the s-d electron cloud. He introduced a dielectric constant $\epsilon(q,\omega)$, and using a very specific model, he was able to prove that in a certain domain $\epsilon(q,\omega)$ is negative, giving thus an attractive interaction between the s electrons. His model leads to an energy gap much too large (0.03 ev) and to a first order transition at $T_c$. In support of Garland, it is shown that generally s-d interaction leads to superconductivity. (W.D.M.)

**11371** CHOICE OF INVARIANT VARIABLES AND ANALYTICAL PROPERTIES OF MANY-POINT FUNCTIONS. V. E. Asribekov. Phys. Letters, 2: 284-6 (Oct. 15, 1962). (In English)

Analytical properties of many-point functions corresponding to the "many-tails" graphs with n-external lines (4-momenta $P_i$, $P_i^2 = M_i^2$) as functions of 3n-10 independent variables can be studied only if the invariant variables are suitably chosen. Scalar square combinations of 4-momenta $P_i$, the so-called "kinematic invariants" are used in this discussion as invariant variables. (W.D.M.)

**11372** A. C. LOSS IN SUPERCONDUCTING LEAD–BISMUTH. R. A. Kamper (Central Electricity Research Labs., Leatherhead, Eng.). Phys. Letters, 2: 290-2 (Oct. 15, 1962). (In English)

Superconductors with inhomogeneous or filamentary structures are able to carry current distributed right across their cross sections. Because of flux-trapping properties, the form of current distribution will in general depend on the previous history of the specimen and, if a-c are carried, hysteresis in the current distribution is to be expected. This is equivalent to a loss of power over a complete cycle. An observation of this loss is reported and information about the current distribution is given. (W.D.M.)

**11373** STATISTICS OF ATOMIC RADIATIVE TRANSITION PROBABILITIES. C. E. Porter (Brookhaven National Lab., Upton, N. Y.). Phys. Letters, 2: 292-3 (Oct. 15, 1962). (BNL-6388). (In English)

A brief preliminary examination of atomic radiative transition probability data recently made available is reported. It is concluded that the number of degrees of freedom in atomic radiative transition probability data is probably small and may not be grossly inconsistent, at least for complex atoms, with one degree of freedom when the accuracy of the data and the possible missing of small levels are taken into account. (W.D.M.)

**11374** CALORIMETRIC MEASUREMENT OF THE AVERAGE ENERGY OF SPUTTERED METAL-ATOMS.

C. H. Weijsenfeld (Universiteit, Utrecht). Phys. Letters, 2: 295-6(Oct. 15, 1962). (In English)

A method was recently developed for determining the average kinetic energy of sputtered particles by directly converting this energy into heat. The bombarding ions were created by a magnetically constricted beam of electrons in a gas of low pressure. Results of preliminary measurements indicate that the average energy of gold atoms sputtered under krypton ion bombardment increases linearly from 10 ev per atom at 400 ev to 20 ev per atom at 1 kev krypton ion energy, after corrections for the heat of sublimation. (W.D.M.)

**11375** INTERMEDIATE ISOTOPE EFFECT OF MOLYBDENUM AND $Mo_3Ir$. B. T. Matthias, T. H. Geballe, E. Corenzwit, and G. W. Hull, Jr. (Bell Telephone Labs., Murray Hill, N. J.). Phys. Rev., 129: 1025-9(Feb. 1, 1963).

The superconducting isotope effect has been investigated in elemental Mo and the compound $Mo_3Ir$. In both cases the transition temperature depends approximately upon the $-\frac{1}{3}$ power of the mass. The significance of such an intermediate effect is discussed. (auth)

**11376** ALLOY CONCENTRATION LIMITATIONS FOR IDEAL SUPERCONDUCTIVITY TRANSITIONS. C. Chiou, R. A. Connell, and D. P. Seraphim (International Business Machines Corp., Yorktown Heights, N. Y.). Phys. Rev., 129: 1070-6(Feb. 1, 1963).

For mean free paths less than 440 ± 100 Å, the dc resistance, magnetic susceptibility, and low-frequency surface impedance data on a series of indium-base alloys (Bi, Pb, Sn, Cd, Tl, Hg) indicate negative interfacial energies between superconducting and normal material. The experiments demonstrate the presence of an intermediate state, normal and superconducting, at magnetic fields much less than $H_c$ as well as the usual filamentary superconductivity at high magnetic fields. Thus, quantitatively, the mean-free-path effect and, qualitatively, the intermediate state effect at low fields are in agreement with the theory of Abrikosov and Gorkov. Data on severely cold-worked high-purity tantalum and on a cold-worked In alloy are compared to the effect of alloying alone. Cold work has only a minor effect in increasing the filamentary critical magnetic field in comparison to the mean-free-path effects in indium alloys. The implications for high-field superconductivity are discussed. (auth)

**11377** DIRECT MEASUREMENT OF THE VACANCIES PRODUCED IN SODIUM CHLORIDE BY FAST REACTOR NEUTRONS. Paul W. Levy (Brookhaven National Lab., Upton, N. Y.). Phys. Rev., 129: 1076-85(Feb. 1, 1963). (BNL-6337)

When unstrained NaCl single crystals are irradiated with gamma rays, reproducible curves of color-center, especially F-center, concentration vs dose can be obtained. At doses of approximately $10^7$ R it appears that all of the negative-ion vacancies in the crystal have been converted into F centers and that they are stable at room temperature. When crystals which have been previously colored with gamma rays to this extent are bombarded with fast neutrons, and then the gamma-ray irradiations are resumed, there is an increase in F center, i.e., vacancy concentration, which is proportional to the total fast neutron flux. The number of vacancies induced by the fast neutron bombardment, determined in this way, is in agreement with the theoretical treatments of Kinchin and Pease, and Seitz and Koehler. (auth)

**11378** ELECTRON TRANSPORT PHENOMENA IN ZINC AT LIQUID-HELIUM TEMPERATURES. C. G. Grenier, J. M. Reynolds, and N. H. Zebouni (Louisiana State Univ., Baton Rouge). Phys. Rev., 129: 1088-1104(Feb. 1, 1963).

The magnetic-field dependences of the electrical and thermal resistances, the thermoelectric power, the Hall, the Righi-Leduc, the Peltier, the Ettingshausen, and the Ettingshausen-Nernst effects at liquid-helium temperatures in magnetic fields up to 14 kG, have been investigated in a single crystal of zinc. The measurements were taken with either a constant heat current or a constant electric current flowing perpendicular to the hexagonal axis with the magnetic field parallel to the hexagonal axis. (auth)

**11379** NUCLEAR MAGNETIC RESONANCE MODES IN MAGNETIC MATERIAL. I. THEORY. P. G. de Gennes (Faculte des Sciences, Orsay, France), P. A. Pincus, F. Hartmann-Boutron, and J. M. Winter. Phys. Rev., 129: 1105-15(Feb. 1, 1963).

In a magnetic medium the nuclear spins are coupled by the Suhl-Nakamura indirect interaction. This interaction is weak but has a very long range b. It is known to contribute to the nuclear spin relaxation. It also gives rise to a displacement of the nuclear magnetic resonance frequency which is important at temperatures in the helium range for materials with a large concentration of nuclei and large b. More generally the indirect interaction gives rise to a spectrum of nuclear spin waves. This spectrum may be shown to be meaningful even when the nuclei are far from order because of the long range of the interaction. Different methods to observe this spectrum are discussed. (auth)

**11380** SPECIFIC HEATS OF TRANSITION METAL SUPERCONDUCTORS. F. J. Morin and J. P. Maita (Bell Telephone Labs., Murray Hill, N. J.). Phys. Rev., 129: 1115-20(Feb. 1, 1963).

Specific heats have been measured on superconducting transition metal elements, alloys and compounds which cover a wide range in $T_c$ and a large portion of the d band. A strong dependence of $T_c$ upon the density of states in the d band indicates that the superconducting electrons are d electrons. The electron interaction parameter, V, of the Bandeen-Cooper-Schrieffer theory is found to be approximately 0.4 ev for all the metals investigated. The phonon frequency involved in the electronic interaction is less than predicted by theory and changes over a range of about a factor of 5 when the Fermi level is moved to different parts of the d band. The product N(O)V exceeds the weak coupling limit for many specimens, yet the results for these do not depart from the general behavior. (auth)

**11381** INTERNAL MAGNETIC FIELDS, ISOMER SHIFTS, AND RELATIVE ABUNDANCES OF THE VARIOUS Fe SITES IN FeSi ALLOYS. M. B. Stearns (Ford Motor Co., Dearborn, Mich.). Phys. Rev., 129: 1136-44(Feb. 1, 1963).

The "Mössbauer" technique was used to measure the internal magnetic fields and isomer shifts of $Fe^{57}$ atoms residing at various sites in the FeSi series. The relative abundances of the various sites present in a given alloy were obtained by measuring the relative intensities of the components in the resolved spectrum of the alloy. Alloys with Si content varying from 0 to ~27 at. % were studied. In the disordered region (<10 at. % Si) three different type sites were observed. These corresponded to Fe atoms having 8, 7, and 6 nearest-neighbor Fe atoms. The internal field decreased by 0.08 $H_{Fe}$ for each Si nearest neighbor. In the ordered region the alloys try to go into a $Fe_3Al$ type structure. Sites having 8 through 3 nearest-neighbor iron atoms were observed. For A-type sites (4 nearest-neighbor Fe atoms and 4 nearest-neighbor Si atoms at 25 at. % Si), the internal field decreased by 0.14 $H_{Fe}$ for each Si nearest

neighbor. Over the whole series the isomer shift indicated that there was progressively less electronic charge density at the origin as the number of nearest-neighbor Si atoms increased. A measure of the relative intensities of the various magnetic field components in the spectra of an alloy series is shown to give direct evidence on the type of ordering. No tendency to form intermediate compounds other than $Fe_3Si$ was observed. An average internal magnetic field for each alloy could be obtained from the data. This average internal field does not vary in the same way as the magnetization on the FeSi series. (auth)

**11382** LATTICE DEFECTS AND THE SELF-DIFFUSION AND ANOMALOUS SPECIFIC HEAT IN SOLID $\alpha$-$He^3$. F. W. de Wette (Univ. of Illinois, Urbana and Argonne National Lab., Ill.). Phys. Rev., 129: 1160-1(Feb. 1, 1963). (TID-17408)

By using a simple model for lattice defects, the hypothesis that the anomalous specific heat and the self-diffusion in solid $\alpha$-$He^3$ are the result of the formation of lattice defects was tested. It is found that vacancies and interstitials are present in about equal numbers and that their formation, probably in pairs, gives rise to the observed specific heat anomaly. It is contended that the motion of the vacancies gives rise to the self-diffusion. (auth)

**11383** RECOMBINATION AND TRAPPING IN NORMAL AND ELECTRON-IRRADIATED SILICON. Joseph A. Baicker (RCA Labs., Princeton, N. J.). Phys. Rev., 129: 1174-80(Feb. 1, 1963).

Both recombination and trapping are observed in normal and irradiated silicon. There combination processes are analyzed on a Shockley-Read model and the energy levels and relative electron and hole capture cross sections of the recombination centers are given. A previously unreported recombination center is produced in p-type silicon by electron irradiation. It is located at $E_v + 0.18$ ev and is a net donor. Four samples of n-type silicon were studied, three of which gave agreement with the results of Galkin ($E_r = E_c - 0.17$ ev), and the fourth gave agreement with the results of Wertheim ($E_r = E_v + 0.27$ ev). A theoretical treatment of trapping in the presence of direct or indirect recombination is presented and shown to give good agreement with the observed trapping behavior. Three distinct trapping levels are seen in n-type silicon. (auth)

**11384** STUDIES OF THE MECHANISM OF ELECTRON-ION RECOMBINATION. [PART] I. Manfred A. Biondi (Westinghouse Research Labs., Pittsburgh). Phys. Rev., 129: 1181-8(Feb. 1, 1963).

Microwave and optical techniques are used to study the loss of electrons during the afterglow following microwave discharges in noble gases, principally in neon and argon. The time and pressure dependences of the electron density decays follow a two-body volume electron-ion recombination law over a wide range of variables, yielding recombination coefficients in the range $10^{-7} - 10^{-6}$ cc/sec for neon and for argon. The afterglow radiation is shown to originate in the volume of the ionized gas, far from the walls, and to decrease in intensity when the electron energy is momentarily increased. Both of these observations are consistent with volume recombination loss of electrons leading to the formation of excited atoms. Further, the intensity of the afterglow radiation is observed to vary in time in the same manner as the square of the electron density, and absolute intensity determinations in neon and in argon yield recombination coefficients consistent with the values obtained from the electron-density decay curves. As a test of the hypothesis that dissociative recombination, $X_2^+ + e \rightarrow X^* + X$, is responsible for the large recombination loss observed in microwave afterglows, measurements are made under conditions first where only $Ar^+$ ions and then where only $Ar_2^+$ ions are expected in the afterglow. The usual large recombination loss of electrons is observed when $Ar_2^+$ ions are present, but at the same charge densities, only ambipolar diffusion loss of electrons and $Ar^+$ ions is observed. (auth)

**11385** NUCLEAR QUADRUPOLE INTERACTION OF $Sb^{121}$ AND $Sb^{123}$ IN ANTIMONY METAL. R. R. Hewitt and B. F. Williams (Univ. of California, Riverside). Phys. Rev., 129: 1188-92(Feb. 1, 1963).

The five nuclear quadrupole resonances of $Sb^{121}$ and $Sb^{123}$ have been measured at 4.2°K giving the quadrupole couplings $eqQ = 76.867 \pm 0.001$ and $97.999 \pm 0.001$ Mc/sec, respectively. The temperature dependence of the interaction has been measured from 2 to 480°K. Both isotopes have the same temperature dependence of $(1/\nu)(d\nu/dT) \approx 2.4 \times 10^{-4}$ °$K^{-1}$. The ionic field gradient provides about 10% of this measured quadrupole coupling. (auth)

**11386** INFLUENCE OF A COMBINED MAGNETIC DIPOLE AND ELECTRIC QUADRUPOLE INTERACTION ON ANGULAR CORRELATIONS. Kurt Alder (Universität, Basel), Eckart Matthias, Werner Schneider, and Rolf M. Steffen. Phys. Rev., 129: 1199-1213(Feb. 1, 1963). (TID-16278)

The general theory of perturbed angular correlations has been applied to the special case of a static combined magnetic dipole and electric quadrupole interaction of comparable strength. Particular emphasis is given to the important case of an external magnetic field applied to a source with randomly oriented electrostatic gradients (polycrystalline source). Expressions for the differential and integral attenuation factors are derived as a function of the ratio $y = \omega_H/\omega_E$ of the magnetic ($\omega_H$) and the electric interaction frequencies ($\omega_E$), and for several values of the electric interaction parameter $x = \omega_E t$ and $x = \omega_E \tau$, respectively. Numerical values for the attenuation factors are computed for the spins, 1, 3/2, 2, and 5/2 for 30 values of y and 24 values of the parameter x. The results are displayed in form of representative curves. As an example of the application of the general results, angular correlation functions are calculated for the two cases of a magnetic field perpendicular to the detector plane and parallel to the emission direction of one of the observed nuclear radiations. (auth)

**11387** PRESSURE SHIFTS OF THE HYPERFINE STRUCTURE OF ATOMIC NITROGEN. R. H. Lambert and F. M. Pipkin (Harvard Univ., Cambridge, Mass.). Phys. Rev., 129: 1233-9(Feb. 1, 1963).

The hyperfine structure of atomic nitrogen in the $(2p)^3$ $^4S_{3/2}$ electronic ground state has been investigated by the spin-exchange optical polarization method. The transmission of circularly polarized rubidium $D_1$ ($5\ ^2P_{1/2} \longleftrightarrow 5\ ^2S_{1/2}$) resonance radiation through a flask containing rubidium vapor, a buffer gas, and atomic nitrogen was observed as a function of the frequency of an applied radio-frequency field. Measurements were made at pressures ranging from 10 to 65 mm Hg in neon, argon, helium, and molecular nitrogen buffer gases. The extrapolated zero-pressure frequency intervals and their corresponding pressure shifts, as determined by the method of least squares, are given. The experimental pressure shifts are compared with a theory recently proposed by Adrain and an expression is derived for the Stark shift of the nitrogen hyperfine structure. (auth)

**11388** ELECTRONIC CHARGE DISTRIBUTIONS FOR HEAVY IONS AT HIGH VELOCITIES. Harry H. Heckman,

Edward L. Hubbard, and William G. Simon (Univ. of California, Berkeley) Phys. Rev., 129: 1240-9(Feb. 1, 1963). (UCRL-10265)

The equilibrium electronic charge-state distributions of $C^{12}$, $N^{14}$, $O^{16}$, and $Ne^{20}$ ions in Zapon at energies between 1.59 and 10.5 Mev/nucleon are measured. The nonequilibrium charge distributions for $Ar^{40}$ ions at 10.2 Mev/nucleon are also given. The experimental technique used makes possible measurements of charge states that comprise less than $10^{-5}$ of the total beam. The quilibrium charge data are satisfactorily interpreted by, and lend support to, the phenomenological theory of Dmitriev. It is found possible to present the ratio of loss to capture cross sections for the 1K, 2K, and 1L electrons and the mean ionic charge for all ions in terms of universal functions involving the ion velocity and ionic and nuclear charge. The relative values of the absolute cross sections for the loss and capture of single electrons by $Ar^{40}$ ions are interpreted by simple statistical arguments. (auth)

**11389** NONADIABATIC THEORY OF ELECTRON-HYDROGEN SCATTERING. [PART] II. A. Temkin and E. Sullivan (National Aeronautics and Space Administration, Greenbelt, Md.). Phys. Rev., 129: 1250-7(Feb. 1, 1963).

The triplet S-wave electron-atomic hydrogen elastic scattering phase shifts are recalculated by a previously introduced nonadiabatic theory. The previous calculation has been improved in a number of respects the most important of which is the utilization of noniterative technique for numerically solving the partial differential equations. (This technique is expected to be useful for a large class of linear second-order elliptic partial differential equations.) Phase shifts are computed to better than four significant figures. The results are quite close to the variational results of Schwartz but on the whole somewhat larger. The deviations are considered signiffcant, and the various approaches are discussed. Specifically the triplet scattering length (in Bohr radii) is $a_t = 1.7683$, with an extrapolated value $a_t = 1.767$. (auth)

**11390** COLLISIONS OF SLOW ELECTRONS AND POSITRONS WITH ATOMIC HYDROGEN. Philip G. Burke, (Univ. of California, Berkeley), Harry M. Schey, and Kenneth Smith. Phys. Rev., 129: 1258-74(Feb. 1, 1963). (UCRL-10382)

The scattering of electrons and positrons by atomic hydrogen was investigated for projectile energies in the range from 11.0 to 54.4 ev. A calculation was performed on (a) the differential and total cross sections for elastic and inelastic scattering, (b) quantities related to polarization and correlation of electron spins, and (c) the polarization of radiation emitted in various electromagnetic transitions. A close-coupling approximation is used in which the total wave function is expanded in hydrogen eigenstates and only terms corresponding to the 1s, 2s, and 2p states are retained; the wave function is symmetrized or antisymmetrized explicitly in the case of electron collisions. In positron interactions, positronium formation is neglected. The coupled integrodifferential equations that result from the approximate wave function are integrated numerically on an IBM-709 or 7090 computer, subject to standard boundary conditions, to yield the reactance matrix elements in each total spin and total angular-momentum state. In the case of electron scattering, the integral terms are treated by means of an iteration procedure. It is found that for elastic 1s-1s electron-hydrogen scattering the inclusion of the 2p state in the close-coupling wave function modifies some partial-wave contributions at lower energies; however, the effect on the total cross section is small. The 1s-1s cross section has a maximum computed value of about $6\pi a_0^2$ at the second quantum excitation energy, and the differential cross section is strongly peaked in the forward direction. For elastic 2s-2s scattering of electrons, calculated total cross sections are exceptionally large, attaining values of the order of $400\pi a_0^2$ at 11.00 ev; here, too, the differential cross section is strongly peaked in the forward direction. The calculated inelastic electron-hydrogen 1s-2p cross sections are in disagreement with experimental results, sometimes by as much as a factor of two. The calculated cross section reaches a maximum of $1.3\pi a_0^2$ at about 20 ev. The predictions for polarization of photons emitted by hydrogen atoms excited by electron bombardment yield a result that, near the n = 2 threshold, is a rapidly varying nonmonatomic function of energy; again, over-all agreement with experimental results is poor. These discrepancies probably can not be reconciled by any close-coupling calculation. Results are presented for the 1s-3p excitation cross section calculated with a 1s-3p close-coupled wave function; there are no experimental data for comparison but the consequences these results have for 1s-2s excitations are pointed out. The calculated total 1s-2s excitation cross sections show little difference as a result of including the 2p state in the close-coupling wave function. Agreement with experiment is again poor although measurements are subject to possible errors in normalization and further investigation of normalization procedures are suggested. As in the elastic case, the differential 1s-2s cross section is strongly peaked in the forward direction. Measurements of the spin-flip cross section and the calculation of it are in fair agreement at the n = 2 threshold. The effect of the 2p state on elastic positron-hydrogen scattering is quite pronounced, especially for energies immediately above the n = 2 threshold. For 1s-2s excitations by positrons, the same effect is seen, but it manifests itself over a wider energy range. Calculated values of reactance matrix elements are provided in tabular form for electron-hydrogen scattering at six energies above threshold. (auth)

**11391** INVESTIGATION OF $Ta_2C$, $Nb_2C$, AND $V_2C$ FOR SUPERCONDUCTIVITY. A. L. Giorgi, E. G. Szklarz, E. K. Storms, and A. L. Bowman (Los Alamos Scientific Lab., N. Mex.). Phys. Rev., 129: 1524-5(Feb. 15, 1963). (LADC-5495)

Previous investigators have reported that $Ta_2C$ and $Nb_2C$ became superconducting at 3.26 and 9.18°K, respectively. In this work, no superconducting transition was found in pure compounds of $Ta_2C$ and $Nb_2C$ for measurements down to 1.98°K, but when the metal phase was present, transition temperatures near the reported transition temperatures were obtained. A sample of $V_2C$, containing a slight excess of metal phase, was prepared and found to have a transition temperature of 4.7°K. However, when the sample was treated with boiling hydrochloric acid to preferentially leach out the metal phase, no superconducting transition was observed for measurements down to 1.98°K. In view of these results, and the similarity between the transition temperature of the metal and the M-$M_2C$ mixture, it appears that pure $Ta_2C$, $Nb_2C$, and $V_2C$ are not superconducting down to 1.98°K.

**11392** NUCLEAR MAGNETIC RESONANCE SATURATION IN LITHIUM. A. G. Redfield and R. J. Blume (Columbia Univ., New York). Phys. Rev., 129: 1545-8 (Feb. 15, 1963).

The real part $\chi'$ of the rf nuclear magnetic susceptibility was measured absolutely for applied rf fields between

0.001 and 5 G, at 77°K and 10.7 Mc/sec. Above the saturation level of 0.02 G the discrepancy between theory and experiment is less than 20%. (auth)

**11393** RADIATION EQUILIBRIUM OF F AND M CENTERS IN KCl. E. Sonder and W. A. Sibley (Oak Ridge National Lab., Tenn.). Phys. Rev., 129: 1578-82(Feb. 15, 1963).

A study of F- and M-center coloration by electron-irradiating single crystals of KCl is made as a function of radiation intensity, electron energy, and crystal preparation. The quadratic relation between M-center and F-center concentration in any particular sample, previously observed for both x-ray and gamma irradiation, is verified for electrons if a constant current is used throughout the irradiation. However, the ratio of M-center concentration to the square of the F-center concentration is dependent upon electron current and sample preparation. Moreover, if a specimen is irradiated at one radiation intensity for a long period and then the intensity is changed for a short time, the relative M- and F-center concentrations are characteristic of the last irradiation intensity. It is concluded from this result that a dynamic equilibrium exists between F centers and M centers during irradiation. Interpretation of the results is proposed in terms of four simultaneous processes producing and destroying F centers and M centers, respectively. The processes for destruction of F centers and creation of M centers are thought to involve a mobile imperfection created by the irradiation. Means by which small concentrations of impurities can affect some of these processes to change the F-M equilibrium and F-center coloring curves are discussed. (auth)

**11394** SELF-CONSISTENT WAVE FUNCTIONS FOR YTTERBIUM. M. W. Holm and E. L. Eichhorn (Burroughs Corp., Pasadena, Calif.). Phys. Rev., 129: 1614-17(Feb. 15, 1963).

Wave functions for the thirteen electron groups of ytterbium have been calculated in the nonrelativistic approximation without exchange. Certain innovations in the numerical procedures are described and discussed. In particular, the use of backward integrations is essentially eliminated from the procedure for determining the energy-related eigenparameters. Wave functions are tabulated for the outermost four subshells, and Slater integrals for the 4f group. The $4f^{14}\ 6s^2$ configuration is assumed. (auth)

**11395** INDIRECT RELATIVISTIC EFFECT ON THE 5f ELECTRONS IN URANIUM. R. G. Boyd, A. C. Larson, and J. T. Waber (Los Alamos Scientific Lab., N. Mex.). Phys. Rev., 129: 1629-30(Feb. 15, 1963). (LADC-5493)

Hartree nonrelativistic atomic wave functions have been calculated for elements 89 through 98. The eigenvalues |E| of the 5f and 6d electrons in uranium were, respectively, 5.69 and 1.06 ev greater than those in the relativistic calculation by Cohen. The energy difference between the 5f and 6d eigenvalues is 4.6 ev greater in the nonrelativistic calculation. Since both the 5f and 6d bands are expected to be partially occupied in metallic uranium and neighboring elements, it is suggested that the results of solid-state calculations for the actinide elements using nonrelativistic crystal potentials will not be even qualitatively correct. (auth)

**11396** POLARIZATION OF OPTICAL RADIATION INDUCED BY ELECTRON IMPACT ON HELIUM. R. H. Hughes, R. B. Kay, and L. D. Weaver (Univ. of Arkansas, Fayetteville). Phys. Rev., 129: 1630-7(Feb. 15, 1963).

An investigation of the polarization of the atomic line radiation induced by electron impact on helium has been undertaken. Experimental data have been obtained on the polarization of several lines as a function of both electron energy and pressure. Secondary excitation processes, such as collision of the second kind and radiative transfer (cascade), are found to play an important role in the polarization. Expressions are derived for the analysis of the pressure effects on the polarization. Gas-kinetic collision cross sections involving atoms in excited states have been determined by observing the depolarization as the gas pressure increases. (auth)

**11397** SECONDARY ELECTRON EMISSION FROM METAL SURFACES BY $H^+$, $H^0$, $He^+$, AND $He^0$ BOMBARDMENTS. S. N. Ghosh and S. P. Khare (Univ. of Allahabad, India). Phys. Rev., 129: 1638-42(Feb. 15, 1963).

Secondary electron emission coefficients for metal surfaces bombarded by $H^+$, $H^0$, $He^+$, and $He^0$, and the ratios $\gamma_{H^0}/\gamma_{H^+}$ and $\gamma_{He^0}/\gamma_{He^+}$ have been calculated. As in a previous paper, it is assumed that internal secondaries are produced by ionization. For the energy range 20 kev to 2 Mev, Bethe's formula for ionization cross section has been modified to the form $Q_B/(1 + \beta/T)$, where $Q_B$ is the ionization cross section given by Bethe's original expression, $\beta$ is a constant, and T is the energy of the incident ion. For a proton beam, the capture cross section becomes appreciable for energy less than 200 kev. Hence, the beam is considered as a two-component system consisting of protons and hydrogen atoms both producing internal secondaries. Above this energy rate, the beam is considered as a one-component system. Similarly, a hydrogen atomic beam has been considered as a three-component system consisting of $H^+$, $H^0$, and electrons, and a helium beam for energy greater than 80 kev as a four-component system consisting of $He^0$, $He^+$, $He^{++}$, and electrons. Below 80 kev, the helium beam is regarded as a mixture of $He^0$, $He^+$, and electrons which produce secondaries by ionization. The calculated secondary electron emission coefficients are compared with experimental data. The agreements are satisfactory as the percentage deviation is only about 10%. (auth)

**11398** FLUCTUATION COMPRESSIBILITY THEOREM AND ITS APPLICATION TO THE PAIRING MODEL. J. S. Bell (Univ. of Washington, Seattle and CERN, Geneva). Phys. Rev., 129: 1896-1900(Feb. 15, 1963).

A theorem of statistical mechanics relates density fluctuations to compressibility. A new derivation of this is given. The theorem is violated in the BCS model of a superconductor. The difficulty is resolved by those same improvements in the theory which lead to a gauge-invariant Meissner effect. (auth)

**11399** SUSCEPTIBILITIES AND CRITICAL FIELDS OF SUPERCONDUCTING FILMS. Werner Liniger and Farouk Odeh (International Business Machines Corp., Yorktown Heights, N. Y.). Phys. Rev. Letters, 10: 47-8 (Jan. 15, 1963).

Calculations are made of susceptibilities and critical fields of superconducting films, using a nonlocal and nonlinear theories. Diffuse scattering boundary conditions and equal applied fields on the two sides of the film are assumed. Both the Pippard and the BCS kernels are considered. Results are also obtained for a combined nonlocal-nonlinear theory. For this theory, the relations between coherence length, critical fields, and type of transitions are studied. This theory also establishes that the critical field varies as the $^3/_2$ power of the film thickness, as the thickness approaches zero. (T.F.H.)

**11400** OSCILLATORY BEHAVIOR OF ULTRASONIC ATTENUATION IN SUPERCONDUCTING Nb–Zr ALLOYS.

Lewis T. Claiborne and Norman G. Einspruch (Texas Instruments, Inc., Dallas).- Phys. Rev. Letters, 10: 49-51 (Jan. 15, 1963).

The attenuation of ultrasonic compressional waves at frequencies of 5 to 30 Mc is studied in superconducting Nb and Nb–Zr alloys. Large fluctuations are observed in the attenuation as the temperature is varied from 1 to 4.5°K. It is concluded that these fluctuations are characteristic of the superconducting state, since application of the critical magnetic field destroys the structure observed; that the fluctuations are probably related to pressure and/or charge-density modulations; that the attenuation is strongly frequency-dependent; and that the attenuation is independent of the sound-wave amplitude at small strains in the frequency range studied. The mechanism underlying the attenuation fluctuations is studied, in terms of the filamentary theory of hard superconductors. (T.F.H.)

**11401** ASYMPTOTIC PROPERTIES OF FIELDS AND SPACE-TIMES. Roger Penrose (King's Coll., London). Phys. Rev. Letters, 10: 66-8(Jan. 15, 1963).

Techniques are studied for treating asymptotic problems in special and general relativity. Attention is devoted to: the geometrical definition of asymptotic flatness; covariant definitions of incoming and outgoing gravitational and other radiation fields; the detailed asymptotic behavior of the Riemann tensor and other fields; characteristics of the total energy-momentum; unification of finite and asymptotic versions of the characteristic initial value problem; and the geometrical derivation of an asymptotic symmetry group. (T.F.H.)

**11402** THEORY OF TORSIONAL OSCILLATIONS IN ROTATING HELIUM. John R. Pellam (California Inst. of Tech., Pasadena). Phys. Rev. Letters, 10: 82-4(Feb. 1, 1963).

An alternative explanation was proposed for the excess second sound attenuation in rotating liquid helium. This treatment replaced effects attributed to quantized vortices by the corresponding effects for irrotational domain behavior. The equations of motion, imposition of boundary requirements, and specification of effective density of superfluid attached to the disks were determined. (C.E.S.)

**11403** PHOTON CORRELATIONS. Roy J. Glauber (Harvard Univ., Cambridge, Mass.). Phys. Rev. Letters, 10: 84-6(Feb. 1, 1963).

General quantum mechanical methods for the investigation of correlation effects were developed, and results for the distribution of the number of photons counted in an incoherent beam were presented. Photoionization probability was examined to discuss photon correlations. Coherent states of the field led to no photoionization correlations. (C.E.S.)

**11404** OBSERVATION OF PERSISTENT CURRENT IN A SUPERCONDUCTING SOLENOID. J. File and R. G. Mills (Princeton Univ., N. J.). Phys. Rev. Letters, 10: 93-6(Feb. 1, 1963). (MATT-146)

Modern nuclear magnetic resonance (NMR) techniques were applied to measure a persistent current in a closed super-conducting circuit. The trapped magnetic field was measured and recorded with time. Two measurements extending over a period of 21 and 37 days respectively, were described. An attempt was made to correlate the data with the flux-creep theory. This experiment was performed in the superconducting portion of the critical state diagram. (C.E.S.)

**11405** GAPLESS SUPERCONDUCTIVITY. J. C. Phillips (Cambridge Univ., Eng.). Phys. Rev. Letters, 10: 96-8(Feb. 1, 1963).

An attempt was made to clarify the meaning of "energy gap" in a superconductor containing paramagnetic impurities. Previous experiments indicated that a metal containing paramagnetic impurities could become superconducting without possessing a well-defined energy gap. This experiment concluded that while magnetic scattering may introduce decaying states into the gap, it need not destroy the peak in the density of states. (C.E.S.)

**11406** THERMAL CONDUCTIVITY OF SUPERCONDUCTORS OF THE SECOND KIND. L. Dubeck, P. Lindenfeld, E. A. Lynton, and H. Rohrer (Rutgers Univ., New Brunswick, N. J.). Phys. Rev. Letters, 10: 98-101(Feb. 1, 1963).

Thermal conductivity was measured as a function of magnetic field in superconducting alloy with sufficiently short mean free path to have a negative interphase surface energy. At temperatures low compared to the superconducting transition temperature, the conductivity went through a pronounced minimum. This behavior was explained in terms of an energy-gap-dependent variation of the lattice and electronic thermal conductivities. (C.E.S.)

**11407** INVERTED CASCADES IN ENERGETIC NEUTRAL HYDROGEN BEAMS. John R. Hiskes (Univ. of California, Livermore). Phys. Rev. Letters, 10: 102-4(Feb. 1, 1963).

A process was described whereby the excitation of excited atoms in collisions with plasma ions and electrons can lead to an upward cascade of the population distribution, resulting in an almost complete Lorentz ionization of these excited states. The cross sections for collisional excitation and de-excitation of the excited states of the hydrogen atom were rapidly increasing functions of principal quantum numbers $n$ and varied approximately as $n^4$. These cross sections were of the order of $10^{-12}$ cm$^2$ for n = 9 in 10-ev electron collisions or 20-kev proton collisions. (C.E.S.)

**11408** RESONANCE IN THE ELASTIC SCATTERING OF ELECTRONS IN HELIUM. G. J. Schulz (Westinghouse Research Labs., Pittsburgh). Phys. Rev. Letters, 10: 104-5(Feb. 1, 1963).

The elastic cross section in helium was examined using electrons with a narrow energy spread. A sharp resonance was found in the scattered electrons at an angle $\Theta = 72°$ at an energy below the onset of the first excited state. A double electrostatic analyzer was used for the experiment. The observation of the resonance in the elastic cross section indicated that compound states played a role in electron scattering by atoms just as they do in neutron scattering by nuclei and electron scattering by molecules. The existence of a compound state has a bearing on calculations of atomic excitation cross sections, particularly near the excitation threshold. (C.E.S.)

**11409** THE POLARIZATION OF ELECTRON IMPACT RADIATION IN HELIUM. D. W. O. Heddle and C. B. Lucas (University Coll., London). Proc. Roy. Soc. (London), Ser. A, 271: 129-42(Jan. 1, 1963).

The excitation and polarization of electron impact radiation have been studied as a function of helium pressure in order to determine conditions for which secondary processes do not cause significant depolarization of the observed radiation. Under these conditions the optical excitation functions and the polarization as a function of electron energy have been determined for a number of transitions. The measurements give zero polarization at the threshold, whereas, in general, finite threshold polarization is predicted theoretically. There is some agreement between an extrapolated threshold and the theoretical prediction. Negative polarization has not been observed. Pos-

sible causes of the threshold discrepancy are discussed. (auth)

**11410** ENERGY SPECTRUM OF LATTICES WITH DEFECTS. II. FREQUENCY SPECTRUM OF LATTICE VIBRATION. Shozo Takeno (Osaka Univ.). Progr. Theoret. Phys. (Kyoto), 28: 33-79(July 1962). (In English)

A systematic investigation of the vibration of a lattice containing isotopic impurities of a single kind is made in terms of the Green's function, and a general expression for the squared-frequency spectrum is obtained from a solution of difference equations, which can be applied to any number of dimensions. For a fixed spacial configuration of impurities, the results yield the spectrum of the main continuum and of the localized modes. When the number of isotopes is few, the frequencies of the localized modes, the criterion for their appearance, and the distribution of in-band frequencies are studied in detail, and the results are applied to a simple cubic lattice. The localized modes caused by a substitutional impurity atom are also studied. In the case of a random distribution of isotopes, the spectrum is obtained in a closed form by means of a graphical method for the perturbation calculations. It is shown that: the perturbation from lighter isotopes causes an impurity band or a tail of the spectrum into the forbidden region; and when heavier isotopes are present, the spectrum in the low-frequency part is increased, while in the high-frequency region a tail is added. The criteria for the appearance of the impurity band and for its merging into the main continuum are obtained. For a simple cubic lattice, the construction of the spectrum is performed. (auth)

**11411** ON THE PHONON-PHONON INTERACTION IN A SYSTEM OF BOSE PARTICLES. Sigenobu Sunakawa, Yoshimatsu Yoko-o, and Hiroshi Nakatani (Osaka Univ.). Progr. Theoret. Phys. (Kyoto), 28: 127-36(July 1962). (In English)

The definite expression of the phonon-phonon interaction in a Bose system is derived up to order $N^{-1}$ in terms of the density operator and its exact canonical conjugate. Some mathematical ambiguity is found in the calculation. The validity of the formalism is discussed from the physical point of view. (auth)

**11412** EFFECTS OF IMPURITY SCATTERING ON EXCITONS IN SUPERCONDUCTOR. Kazumi Maki and Toshihiko Tsuneto (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 28: 163-72(July 1962). (In English)

Effects of impurity scattering on excitons (transverse collective excitations) in a superconductor are discussed with the help of the Green's function formalism. The binding energy of the excitons with zero total momentum is obtained explicitly in the limit of both low and high impurity concentration. Discussions are also given on excitons having a finite momentum. It is shown that the primary effect of the scattering is to shift the energy of the excitons, while their damping is not appreciable. Since the shift is rather drastic, it seems unlikely that the subsidiary absorption maximum of infrared radiation observed in some superconductors is produced by excitons. (auth)

**11413** ELECTRICAL RESISTIVITY ASSOCIATED WITH SCREW-TYPE SPIN ARRANGEMENTS. Hirosi Miwa (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 28: 208-10(July 1962). (In English)

The effect of a screw-type spin ordering on electrical resistivity, as a consequence of interaction between localized spins and conduction electrons, is calculated. The electrical resistivity of Er is calculated by this method between 0 and 130°K as an example, and the results are compared with experimental data. (T.F.H.)

**11414** COLLECTIVE MOTION OF PARTICLES AT FINITE TEMPERATURES. Hazime Mori (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 28: 763-83(Nov. 1962). (In English)

A quantum statistical theory of frequency spectra and damping constants of the collective motion of interacting particles at finite temperatures is presented and used to clarify several problems. The formulation is based on the explicit recognition of the fact that a set of collective variables properly chosen describes the collective motion in such a way that the average values of the collective variables at a time determine their average values thereafter. The frequency distribution of the density fluctuations in fluids is thus analyzed, and molecular expressions for the intensities and widths of the spectral lines are obtained. The widths are written in terms of generalized transport coefficients which depend upon the wavelength of the collective oscillation or the frequency spectrum. The expressions are valid even in the case in which the hydrodynamical description is inapplicable, and turn out to be useful for describing the sound attenuation in liquid helium II at low temperatures and the inelastic scattering of neutrons by liquids. The transport coefficients of fluids are formulated in terms of equilibrium fluctuations from a new point of view without the use of the local equilibrium ensemble. The results for the shear viscosity and thermal conductivity agree with those obtained previously. A new term, however, is found to be added to the dynamical flux determining the bulk viscosity. This term arises as a result of subtracting a pressure fluctuation associated with the fluctuation of the mass and energy densities to define a random force. (auth)

**11415** ULTRASONIC ATTENUATION IN LIQUID HELIUM. Kyozi Kawasaki and Hazime Mori (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 28: 784-802(Nov. 1962). (In English)

The attenuation of the first sound in helium II, expressed in terms of the time fluctuation of the force acting on the relevant normal coordinate, is studied from the quantum-hydrodynamical point of view, and is shown to serve for determining the effective interaction between phonons at low temperatures. The attenuation constant calculated is in quantitative agreement with the observed values by Chase and Herlin at a frequency of 12 Mc/sec in the temperature region below about 0.8°K, where Khalatnikov's theory does not work at all. Below 0.4°K, the dependence of the attenuation constant on temperature and frequency is the same as that obtained previously by several authors. The effective interaction here obtained is not quite the same as that obtained with the use of the so-called quantum hydrodynamics. This situation may be analogous to that encountered in determining the effective interaction responsible for the damping of ferromagnetic spin waves. Since the hydrodynamical treatment of the sound wave cannot be applied in the region of interest and the nature of the sound wave is not yet completely clear, both adiabatic and isothermal cases are investigated, and it is shown that the isothermal description is better for treating the sound attenuation below about 0.8°K. (auth)

**11416** THE ASYMPTOTIC BEHAVIOR OF PERTURBATION EXPANSIONS IN MANY-BODY PROBLEM AND THE SUPERCONDUCTING STATE. Kenji Fukushima and Nobuyuki Fukuda (Tokyo Univ. of Education). Progr. Theoret. Phys. (Kyoto), 28: 809-19(Nov. 1962). (In English)

The convergence problem of perturbation expansions in the many-body problem is discussed by employing some simple models. The expectation value of the resolvent operator is analytic around the origin of the coupling constant

so long as the system is enclosed in a finite volume, but as the volume tends to infinity with the density of particles kept constant, the question arises whether this limit is allowed to be taken prior to the sum of the perturbation series Even if this is the case, the resulting series turns out to be usually divergent, but in some models it is thought that a function whose asymptotic expansion coincides with this series can be found. It is shown that for the repulsive interactions the function thus obtained gives a correct answer, while for the attractive interactions which lead to a superconducting state it is far from the true one. The asymptotic behavior of the perturbation series in the latter case is examined in some detail. (auth)

**11417** g-SHIFT AND ANOMALOUS HALL EFFECT IN GADOLNIUM METALS. Jun Kondo (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 28: 846-56(Nov. 1962). (In English)

It is shown that the coupling between spins of conduction and localized electrons due to a covalent mixing between them can be expressed by a usual exchange type interaction with negative (antiferromagnetic) sign. It is proposed that the mixing effect is large in gadolinium metal under the assumption that the energy level corresponding to a trivalent gadolinium ion is very near and below the Fermi surface. Then it is shown that the mixing effect gives rise to a large negative g-shift for the localized spin, which substantially cancels the positive g-shift which comes from the exchange interaction, thus leading to a good agreement with the observation. Furthermore, by introducing a spin-orbit coupling of localized electrons, an anisotropic interaction between conduction and localized electrons can be obtained, which is found to account for a large anomalous Hall effect observed in gadolinium metal. (auth)

**11418** ON DIRTY SUPERCONDUCTORS. Toshihiko Tsuneto (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 28: 857-69(Nov. 1962). (In English)

The mean free path effect of nonmagnetic impurities on superconductors is studied. It is shown by including the impurities in the electron-phonon system that, contrary to the results of the earlier theories, there is no change in the transition temperature which is of the order of $1/\omega_c\tau$, where $\omega_c$ is the cutoff frequency of the BCS theory and $\tau$ the relaxation time in the normal state due to the scattering. The same effect on the superconductor with the anisotropic energy gap is studied explicitly. The scattering in this case leads to the reduction of the transition temperature which is initially linear in $1/\tau$ but becomes logarithmic when $\tau T_c < 1$. The gap in the excitation spectrum is shown to become isotropic when the mean free path is smaller than the coherence length. Thus, Anderson's theory of dirty superconductors is formulated and justified. (auth)

**11419** ON THE STABILITY OF MOLECULES IN THE THOMAS-FERMI THEORY. Edward Teller (Univ. of California, Berkeley). Rev. Mod. Phys., 34: 627-31(Oct. 1962).

The Thomas-Fermi model has been used in approximating the properties of molecules. On the other hand, no stable equilibrium has been found in a calculation applying the Thomas-Fermi-Dirac model to the $N_2$ molecule. A proof is given that statistical models cannot give rise to lower energies in the molecular state than obtained for the separated atoms. The proof applies to the stability of both neutral molecules and under certain conditions to positive molecular ions. (W.D.M.)

**11420** CRITIQUE OF THE HEITLER-LONDON METHOD OF CALCULATING SPIN COUPLINGS AT LARGE DISTANCES. Conyers Herring (Bell Telephone Labs., Murray Hill, N. J.). Rev. Mod. Phys., 34: 631-45(Oct. 1962).

The object of this review is to clarify the status of the spin Hamiltonian and of the Heitler-London method of calculating the constants entering into it for the limiting case to which the original derivations were intended to apply, namely, the case of well-separated atoms. A rigorous justification of the concept of a spin Hamiltonian, a physical picture of the virtues and limitations of the Heitler-London approach, and a prescription for exact a priori calculation of the limiting exchange coupling are given. (W.D.M.)

**11421** CRITICAL FIELDS AND CURRENTS IN SUPERCONDUCTORS. John Bardeen (Univ. of Illinois, Urbana). Rev. Mod. Phys., 34: 667-81(Oct. 1962).

To determine critical fields and currents in small superconducting specimens, it has long been recognized that it is necessary to take into account the effect of a change in the order parameter with field or current. This review is primarily concerned with small specimens of dimensions less than the coherence distance, so that changes in the energy gap with position may be neglected. One may then extend the theory to arbitrary temperatures by treating the gap as a variational parameter and finding the value which makes the free energy a minimum for given fields or currents. (W.D.M.)

**11422** ENERGY SPECTRUM OF ELEMENTARY EXCITATIONS IN HELIUM II. H. W. Jackson and E. Feenberg (Washington Univ., St. Louis). Rev. Mod. Phys., 34: 686-93(Oct. 1962).

The contribution of phonon-phonon interaction to the energy of elementary excitations in liquid $He^4$ is evaluated in the approximation of the Brillouin-Wigner second order energy. The three-particle distribution function p(1,2,3) occurring in the interaction matrix elements is approximated by the Kirkwood superposition form and also by the "convolution" form. A general criterion is developed to test the accuracy of possible approximations for p(1,2,3). The criterion has the form of a functional X in p(1,2,3) which vanishes if p(1,2,3) is generated by the correct ground state solution of the Schrödinger equation. If an approximate form is used the corresponding functional $X_a$ does not vanish and thus provides a measure of accuracy. The power of this criterion resides in the fact that $X_a$ is a function of three variables, the magnitudes of two wave vectors and the cosine of the angle between them. The computed dispersion curves are compared with the experimental curve constructed by Henshaw and Woods from the inelastic single scattering of slow neutrons in liquid helium. (auth)

**11423** CONCEPT OF OFF-DIAGONAL LONG-RANGE ORDER AND THE QUANTUM PHASES OF LIQUID He AND OF SUPERCONDUCTORS. C. N. Yang (Inst. for Advanced Study, Princeton, N. J.). Rev. Mod. Phys., 34: 694-704 (Oct. 1962).

This review is concerned with the concept that in a many-body system of bosons or fermions, it is possible to have an off-diagonal long-range order of the reduced density matrices in the coordinate space representation. The onset of such an order leads to a new thermodynamic phase of the system. It is reasonable to assume that superfluid He II and the superconductors are phases characterized by the existence of such an order. (W.D.M.)

**11424** SHOCK WAVES AND HIGH TEMPERATURES. Malcolm McChesney. Sci. Am., 208: No. 2, 109-19(Feb. 1963).

The understanding of the condition and behavior of atoms and molecules in such extreme states of excitation is fundamental in the fields of thermodynamics and rocketry. The shock tube used in the laboratory for the generation and movement of shock waves can heat a gas to temperature approaching the thermonuclear range. The shock tube provides an excellent means of confronting theory with experiment in connection with the important process of intermolecular energy exchange and the study of molecular dissociation. A detailed discussion of shock tube construction and operation with graphic and schematic diagrams of the various types of shock waves are presented. (H.G.G.)

**11425** CERTAIN PHYSICAL CONSEQUENCES OF THE THEORY OF THE QUANTIZED FIELD OF PROBABILITY AMPLITUDE. I. V. Khimich, Yu. M. Lomsadze, and I. Yu. Krivskii. Ukr. Fiz. Zh., 7: 973-4(Sept. 1962). (In Ukrainian)

On the basis of a physical interpretation of the vector of state in the theory of the quantized field of probability amplitude, an algorithm is developed for the calculation by the theory of magnitudes observed in the usual set-up of the experiment. The general structure of effective cross sections obtained in the theory is elucidated by means of this algorithm within the framework of the perturbation technique. It is shown that the results of the calculation by the theory of magnitudes observed in the usual set-up of the experiment more exactly agree with the results of the usual theory of quantized fields, the lower the individual errors of the measurements of the total set of dynamic variables of the initial state of the physical system. A number of considerations as to the physical essence of the theory are presented. (auth)

**11426** BREAKDOWN VOLTAGES IN AIR (760 TORR) IN HOMOGENEOUS FIELDS (7 TO 30 CM GAP). Hans Sohst (Universität, Hamburg). Z. Angew. Phys., 14: 620-7 (Oct. 1962). (In German)

Investigations of the discharge mechanism in moist air at atmospheric pressure (10 Torr water vapor) in homogeneous fields at electrode gaps of 7 to 30 cm were carried out. Pulse voltages with amplitudes from about 200 up to 1,000 kv (rise time of 0.8 $\mu$ sec and fall time of 3 msec) were produced with a Marx pulse generator. The voltage amplitudes and formation time were measured with a two-stage capacitive voltage divider with a Tektronix oscillograph. The relative accuracy obtained for the voltage measurements was $\pm 10^{-3}$ and the absolute error was $\pm 1.5 \times 10^{-2}$. The formation times were measured with an accuracy of ±5%. The temperature and humidity were maintained at constant values. The breakdown voltage was measured on a spark gap (total diameter 150 cm, diameter of the plain part 50 cm, and plane copper electrodes with Rogowski profile) in the gap range from 7 to 30 cm. A comparison with the measurements of other authors, which were carried out up to 16 cm, shows agreement within the measurement accuracy. Up to 10 cm electrode gap the breakdown field strength remains almost constant (25.8 kv/cm). Formation times were measured as a function of the overvoltage. The times found indicate that in the vicinity of the static voltage, the discharge proceeds by a mechanism similar to the modified channel formation. At overvoltages of 2 to 3% the formation time declines so much that the discharge can be explained as single avalanche formation. At gaps over 10 cm weak dependence of the formation time on the gaps was observed. (tr-auth)

**11427** THE CALCULATION OF THE AXIS TEMPERATURE OF CYLINDRICAL ARCS IN STRONG RADIATION. Hans-Juergen Hentschel (Technische Hochschule, Karlsruhe, Ger.). Z. Angew. Phys., 14: 627-31(Oct. 1962). (In German)

From the assumption that in arcs with strong radiation and low heat conduction from the arc interior the axis temperature is determined through the equilibrium between electrical and radiation output, a method was developed that permits a simple calculation of the axis temperature. The application to xenon high-pressure arcs lead to agreement with other temperature determinations within the uncertainty of such calculations. (tr-auth)

**11428** MASS SPECTROMETRIC INVESTIGATION OF BEAMS FROM CONDENSED HYDROGEN. W. Henkes (Technische Hochschule, Karlsruhe, Ger.). Z. Naturforsch., 17a: 786-9(Sept. 1962). (In German)

By mass spectrometric studies, a determination was made of the composition that the agglomerate present in a condensed hydrogen molecular beam must have to overcome an ionization by electron collision and auxiliary electron acceleration. The largest observed M/Z value was 1100, corresponding to a single charged agglomerate of 550 molecules. This value was entirely given through the upper limit of the measurement range of the spectrometer. With an increase of the electron energy from 60 to 100 ev, the intensity increases at small masses to the cost of the large masses. It therefore follows that the agglomerate was partially shattered by electron bombardment. (tr-auth)

**11429** GENERALIZATION OF THE PLANCK RADIATION LAW IN h-c-l THEORIES. M. Strauss (Deutsche Akademie der Wissenschaften, Berlin). Z. Naturforsch., 17a: 827-47(Oct. 1962). (In German)

In earlier works some results were reported relative to the generalization of Planck's radiation law through a consideration of a third natural constant l. A coherent representation of this question complex is given. In Part I the principles necessary to a generalization of the Planck law are again explained. In Part II a general thermodynamic spectral theory for single-phase systems was developed with one thermodynamic degree of freedom. In Part III the same problem was investigated from the standpoint of statistical thermodynamics. Part IV develops the axiomatic construction of the theory and gives a general discussion of the results. Part V is devoted to questions of model interpretations. The principal results of the study (generalized radiation law and consistency conditions) includes indications on the nature of an artificial h-c-l electrodynamics and can be used reversed as permissive criteria for h-c-l theories. (tr-auth)

**11430** DRIFT VELOCITIES OF IONS AND ELECTRONS IN ARGON AND HYDROGEN. G. Jaeger and W. Otto (Universität, Hamburg). Z. Physik, 169: 517-25(1962). (In German)

Short light sparks release 10 nsec pulses of $10^5$ electrons each which initiate electron avalances in high purity argon and hydrogen. The transit times of the avalances are measured and thus the drift velocities of ions and electrons derived. There is general agreement with available results of other authors. (auth)

**11431** ELECTRIC DISCHARGES BY MIXING XENON WITH HYDROGEN OR HELIUM. Hermann Strub (Technische Hochschule, Karlsruhe, Ger.). Z. Physik, 170: 26-46(1962). (In German)

The effect of He and $H_2$ additions on the Xe high pressure discharge was investigated. Both gases participate only indirectly as "buffer gases" in the discharge. Because of their large momentum exchange with electrons, they lower the electron mobilities and cause, therefore an increase of the voltage gradient of the positive column of

the discharge, which is independent of the base gas pressure. The ratio between the electrical and optical arc cross section could be determined from the temperature dependence of the electrical conductivity calculated for the gas mixture and the light density pattern measured across the arc axis. Therefore it was possible to calculate a mean electrical conductivity from the experimentally determined arc magnitudes and with this to estimate the channel temperature of a simplified arc model in dependence on the partial pressure of the gas additions. Hydrogen additions affect the xenon discharge much more than the helium addition. With hydrogen additions, an output concentration occurs because of a strong contraction of the discharge from the dissociation heat conduction of the dissociated hydrogen almost completely dissolved in the arc. The increased output could compensate, up to a certain partial pressure, the increased output could compensate, up to a certain partial pressure, the increased heat conductivity loss. The luminescent yield increases up to a maximum value, but always remains smaller than that of a pure xenon arc of equal output. (tr-auth)

**11432** STATICAL BOUNDARY PROBLEMS FOR A HOLLOW CYLINDER OF FINITE LENGTH. II. NUMERICAL RESULTS. L. A. Wainswtein (Inst. of Problems in Physics, Moscow). Zh. Tekhn. Fiz., 32: 1157-64(Oct. 1962). (In Russian)

Numerical solutions were found for three electrostatic problems associated with finite conducting cylinders. The first problem deals with the volume of a charged cylinder, the second and third with cylinder polarization in longitudinal and in transverse field. The calculations were made using the Ural-1 memory device. Correlations of numerical results and asymptotic formulas were correlated, and the properties of cylinder are compared. Graphs illustrating charged distributions along the cylinder are included. (tr-auth)

**11433** STATICAL BOUNDARY PROBLEMS FOR A HOLLOW CYLINDER OF FINITE LENGTH. III. APPROXIMATE FORMULAS. L. A. Wainswtein (Inst. of Problems in Physics, Moscow). Zh. Tekhn. Fiz., 32: 1165-73(Oct. 1962). (In Russian)

Asymptotic formulas were developed for long hollow cylinders and the formulas are compared with numerical calculations. (R.V.J.)

**11434** A NEW METHOD FOR THE SOLUTION OF THE PROBLEM ABOUT DIFFRACTION OF ELECTROMAGNETIC WAVES ON A WEDGE OF FINITE CUNDUCTIVITY. N. N. Lebedev and I. P. Skalskaya (Inst. of Physics and Tech., Leningrad). Zh. Tekhn. Fiz., 32: 1174-83(Oct. 1962). (In Russian)

It is shown that in the case of high conductance, resolved using an approximation with impedance boundary conditions, the application of special transformation results in functional equations. The equations were used for resolving the problem of plane electromagnetic wave diffraction by a wedge at various angles. (tr-auth)

**11435** THERMOION EMISSION OF METALS IN DIFFERENT GASES. Ya. M. Fogel, L. P. Rekova, and V. Ya. Kolot (Khar-kov State Univ.). Zh. Tekhn. Fiz., 32: 1259-65 (Oct. 1962). (In Russian)

Effects of various gases ($O_2$, $H_2$, $CCl_4$, $NH_3$, and air) on Ni and Pt thermionic emission were investigated. Tests using $CCl_4$ vapor on annealed Ni in an air stream under atmospheric pressure showed that variations in thermion total current after pumping out the emitter gas, resulted from changes in alkali metal emission ions. Simultaneous studies of thermionic emission total current and the different components of the current separated by mass spectrometer showed, in the case of annealed Pt at $\sim 10^{-4}$ mm Hg, that all variations in thermionic emission correspond to variations in alkali metal ion emissions. (R.V.J.)

**11436** THERMOELECTRON EMISSION OF $HfB_2$, HfC, $HfO_2$, VC, AND SOLID SOLUTION $(UC)_1$ $(ZrC)_4$. T. L. Matskevich, A. P. Kazantsev, and T. V. Krachino (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Tekhn. Fiz., 32: 1266-74(Oct. 1962). (In Russian)

Thermoelectron yields of HfC, $HfO_2$, $HfB_2$, VC, and $(UC)(ZrC)_4$ were calculated by extrapolation of total current to zero field. Variations with temperature were analyzed. Measurements on $HfB_2$ and HfC in the presence of cesium are also tabulated. (tr-auth)

**11437** KINETIC THEORY OF A DIODE FILLED WITH A RAREFIED PLASMA. R. A. Kucherov and L. E. Rikenglas (Inst. of Physics and Tech., Academy of Sciences, Georgian, SSR). Zh. Tekhn. Fiz., 32: 1275-84(Oct. 1962). (In Russian)

Distribution potentials in diodes filled with rarefied plasma were determined under the assumption that the potential in the intra-electron space is nonmonotonic and considering the captured particles in traps developed wear potential extrema. Solutions are given for some cases of particle distribution with large Boltzmann numbers. Diagrams of volt-amp characteristics were constructed and electromotive forces were calculated. (tr-auth)

**11438** SOME AUTOMODEL PROBLEMS OF MAGNETOHYDRODYNAMICS WITH AXIAL SYMMETRY. G. P. Dikii and I. E. Tarapov (Khar'kov State Univ.). Zh. Tekhn. Fiz., 32: 1302-12(Nov. 1962). (In Russian)

An analysis was made of an automodel solution for magnetohydrodynamic problems of axially-symmetric, viscous, finite-conductivity fluid. An explicit problem was resolved for the attenuation of certain formations in an infinite fluid. (R.V.J.)

**11439** SOME STATIONARY PROBLEMS OF MAGNETOHYDRODYNAMICS WITH AXIAL SYMMETRY. G. P. Dikii and I. E. Tarapov (Khar'kov State Univ.). Zh. Tekhn. Fiz., 32: 1333-41(Nov. 1962). (In Russian)

A normalized solution was derived for a stationary, axial-symmetry problem in magnetohydrodynamics. The derived equation was used for resolving problems of conducting flow in an infinite space with a vortex and of flow between two coaxial cylinders. (R.V.J.)

**11440** PRODUCTION OF MAGNETIC FIELDS BY USE OF CURRENT. G. N. Vyalov. Zh. Tekhn. Fiz., 32: 1361-70(Nov. 1962). (In Russian)

Production of a given field by a plane current in a multilayer magnet was studied. Precise expressions were derived for the current density in a two-boundary case (the field in the gap and the field behind a magnetic screen) and for an arbitrary magnetic field in the absence of boundaries (R.V.J.)

**11441** OSCILLATION OF IONS NEAR MINIMUM OF THE POTENTIAL AND LOW-FREQUENCY OSCILLATION IN A GAS DISCHARGE. M. D. Gabovich and G. S. Kirichenko (Inst. of Physics, Kiev). Zh. Tekhn. Fiz., 32: 1376-81(Nov. 1962). (In Russian)

Oscillation properties of cesium and mercury vacuum diodes were studied. It was found that ion oscillations at minimum potential induced anode current oscillations in a vacuum diode with cesium vapor at low pressure and also caused low-frequency oscillations in glowing cathode discharge. (R.V.J.)

**11442** POLUCHENIE I ISPOL'ZOVANIE BOL'SHIKH IMPUL'SNYKH MAGNITNYKH POLEI (SBORNIK REFER-

ATOV 1923-1961 gg). Production and Applications of Strong Pulse Magnetic Fields. (Compilation of Abstracts for 1923 to 1961). S. A. Smirnov and Yu S. Pavlov, eds. Moscow, Gosatomizdat, 1962. 56p.

One-hundred-eighty abstracts are included in chronological order. The compilation covers the most pertinent articles on the production of strong magnetic fields published during 1923 to 1961. An author index is included. (R.V.J.)

**11443** A COMPUTER PROGRAM FOR ANALYSIS OF COMPLEX CONTINUOUS BETA-RAY SPECTRA. S. B. Burson, R. G. Helmer, and T. Gedayloo (Argonne National Lab., Ill.). Oct. 1962. Contract [W-31-109-eng-38]. 19p. (UAC-6952). (TID-17779). (ORINS)

To be published in NAS-NS-3107, Proceedings of the Symposium on Applications of Computers to Nuclear and Radiochemistry, Gatlinburg, Tenn., Oct. 18-19, 1962.

The second stage of a two-stage computer program (IBM-704), developed for analysis of complex beta spectra, is described. It is noted that the first stage accomplishes standard data reduction. (J.R.D.)

**11444** ANALYSIS OF GAMMA-RAY SPECTRA. J. E. Monahan, S. Raboy, and C. C. Trail (Argonne National Lab., Ill.). Oct. 1962. Contract [W-31-109-eng-38]. 9p. (UAC-6951). (TID-17631). (ORINS)

To be published in NAS-NS-3107, Proceedings of the Symposium on Applications of Computers to Nuclear and Radiochemistry, Gatlinburg, Tenn., Oct. 17-19, 1962.

A technique for fitting which was used in the analysis of discrete gamma spectra is described. An algorithm is also described for the approximate solution of problems in quadratic programming. (J.R.D.)

## Astrophysics and Cosmology

**11445** (NASA-TN-D-1685) THE ORIGIN OF ATMOSPHERIC XENON. A. G. W. Cameron (National Aeronautics and Space Administration. Goddard Inst. for Space Studies, New York). Feb. 1963. 4p.

Some of the differences in the isotopic composition of atmospheric and meteoritic xenon can be attributed to irradiation of solar xenon by neutrons during the deuterium burning phase of solar contraction, which was followed by accretion of the irradiated xenon into the atmosphere. This problem was examined in view of a measurement which was made of the reaction rate for the capture of protons by deuterium. It was concluded that, apart from the xenon produced by the decay of extinct radioactivities, most of the atmospheric xenon was in the sun during the deuterium burning phase. (auth)

**11446** NEUTRINO PAIR EMISSION BY A STELLAR PLASMA. J. Barclay Adams, Malvin A. Ruderman, and Ching-Hung Woo (Univ. of California, Berkeley). Phys. Rev., 129: 1383-90(Feb. 1, 1963). (UCRL-10343)

Various current models and generalizations of a universal weak Fermi interaction predict a first-order weak coupling between electrons and $\nu$-$\bar{\nu}$ pairs. The radiation of such pairs by a hot, partially degenerate relativistic plasma is calculated for temperatures and densities that appear to be relevant for stellar evolution. Neutrino-pair emission by collective electron modes, especially transverse plasma excitations, is found to be the main mechanism for neutrino radiation by a dense stellar plasma when electron-positron production is small either because the temperature is too low ($T \lesssim 10^8$ °K) or degeneracy supresses it. The neutrino luminosity of a star can greatly exceed its photon luminosity for a central core temperature greater than $10^8$ °K. (auth)

**11447** MEASURING PLASMA DENSITY OF THE MAGNETOSPHERE. K. L. Bowles (Jicamarca Radar Observatory, Lima). Science, 139: 389-91(Feb. 1, 1963).

The incoherent scattering of incident radio energy by free electrons at high altitudes is useful for measuring plasma density and kinetic temperatures in the magnetosphere. The radio wave resolves a particular spatial Fourier component of the plasma-density fluctuations that is approximately proportional to the ionization density in the region where the scattering occurs. Echoes are obtained from all parts of a volume filled with plasma without mutual interference since this scattering is very weak. Thus, through the use of pulsed radar, the electron density can be measured as a function of distance. The range resolution of the measurement is proportional to the length of the pulse. A large radar station, the Jicamarca Radar Observatory, near Lima, Peru, was established primarily to make incoherent scatter studies of the earth's upper atmosphere and determine the usefulness of these observations in a general study of plasma instabilities. Electron density profiles for varying altitudes obtained by the Jicamarca Radar Observatory are presented. (H.G.G.)

## Cosmic Radiation

**11448** (BNL-6545) COSMIC RAY PRODUCED $Ar^{37}$ AND $Ar^{39}$ ACTIVITIES IN RECENTLY FALLEN METEORITES. Raymond Davis, Jr., R. W. Stoenner, and O. A. Schaeffer (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT-30-2-GEN-16]. 19p. (SM-33/9)

A review of methods for determining meteorite ages is presented. It is noted that the test of spatial variation that can be obtained from recently fallen meteorites is information that requires two years of space vehicle travel time to gather. Data obtained in the examination of five recent meteorites are included. Analysis of data leads to the conclusion that cosmic-ray intensity at several astronomical units from the sun is within 15% of the intensity at the earth's orbit. It is recommended that the accuracy of measurements be checked by the $Ar^{37}/Ar^{39}$ ratio in iron meteorites. (J.R.D.)

**11449** (ML-975) REVIEW OF THE INTERACTION BETWEEN THE GEOMAGNETIC FIELD AND THE SOLAR CORPUSCULAR RADIATION. R. Blum (Stanford Univ., Calif. Microwave Lab.). Nov. 1962. Contract AF49 (638)-342. 71p.

The interaction between the geomagnetic field (GMF) and the solar corpuscular radiation (SCR) is investigated. Particular attention is given to the effect of variations of the SCR on production of geomagnetic storms and auroras and to the subject of an interface separating the GMF from the SCR. Mathematical treatment of three models for the GMF-SCR interaction are presented. (128 references.) (D.C.W.)

**11450** TIME VARIATIONS IN EXTENSIVE AIR SHOWERS. B. G. Wilson and D. B. Swinson (Univ. of Alberta, Calgary). Can. J. Phys., 41: 183-8(Jan. 1963).

Anisotropies in time of energetic primary cosmic radiation are investigated by analyzing 280,000 air showers detected with an extensive-shower detector of 18 Geiger counters. Little evidence for a diurnal variation is seen in sidereal time while variations in solar time seem to be due to fluctuations in the data, not to any correlation with the semidiurnal pressure waves. (D.C.W.)

**11451** PERTURBATION OF THE LOCAL ELECTRON DENSITY BY ALOUETTE SATELLITE. E. Warren (De-

fence Research Telecommunications Establishment, Ottawa). Can. J. Phys., 41: 188-9(Jan. 1963).

Analysis of data from the Alouette satellite yields information on the electron density around the satellite, perturbation of the plasma by the satellite and its effect on communications, and propagation of extraordinary electromagnetic waves through the plasma. Ionograms also reveal a plasma spike near the frequency at which the extraordinary wave begins to propagate. Spikes are also observed at multiples of the electron gyrofrequency. Electron density and the magnitude and direction of the earth's magnetic field at the satellite can be derived from the plasma and cyclotron information. Some variations of F-spread echoes are noted as is the presence of an ionization cloud detected by movement of the diffuse trace. (D.C.W.)

**11452** A PRELIMINARY STUDY OF THE ELECTRON DENSITY AT 1000 KILOMETERS. E. L. Hagg (Defence Research Telecommunications Establishment, Ottawa). Can. J. Phys., 41: 195-9(Jan. 1963).

Study of data from the DRTE satellite on electron densities at the satellite and at the F-layer maximum reveals little day-to-day variation at 1000 km but large variations at the F-layer maximum, depending on the degrees of latitude. A magnetic disturbance during the period considered reduced the electron density. Electron densities at satellite and F-layer heights are displayed. (D.C.W.)

**11453** THE RELATIONSHIP OF F-LAYER CRITICAL FREQUENCIES TO THE INTENSITY OF THE OUTER VAN ALLEN BELT. D. B. Muldrew (Defence Research Telecommunications Establishment, Ottawa). Can. J. Phys., 41: 199-202(Jan. 1963).

An attempt is made to correlate an increase in ordinary-wave critical frequencies of the F-layer with variation in particle densities of the outer Van Allen belt during a magnetic storm. Electrons of energy greater than the 300 kev in the outer Van Allen belt are thought to be a significant source of F-layer ionization. (D.C.W.)

**11454** INVESTIGATIONS OF ENERGETIC PARTICLE INTERACTIONS WITH ATOMIC NUCLEI AT MOUNTAIN ALTITUDES. N. L. Grigorov (Moscow Univ.), C. A. Tretyakova, V. J. Shestopierov, C. P. Babayan, N. G. Bayadsyan, J. Babecki, J. Losklewicz, J. Massalski, and A. Oles. Nukleonika, 7: 759-67(1962). (In English)

An investigation with an apparatus having an area of 10 $m^2$ at 3200 m above sea level indicated that there existed interactions of nuclear particles with nuclei in which the generating particle transferred in one interaction most of its energy to $\pi^0$ mesons. The part of energy transfered to $\pi^0$ mesons was subject to large fluctuations, reaching sometimes as much as 100%. (auth)

**11455** CHANGE IN THE RIGIDITY SPECTRUM DURING SHORT-TERM VARIATION OF COSMIC RAYS. Hachiro Takahashi (Iwate Univ., Morioka, Japan). Phys. Rev. Letters, 10: 116-17(Feb. 1, 1963).

It was determined that the relative change of the cosmic-ray intensity has a good correlation with geomagnetic disturbances observed on the earth. It was concluded that the cosmic-ray rigidity spectra change exponentially with geomagnetic disturbance in the short-term period, and such changes were supposed to be caused mainly by magnetic clouds emitted from the sun. (C.E.S.)

**11456** THERMODYNAMICAL CONSIDERATION ON THE SPECTRUM OF COSMIC RAYS. Humitaka Sato (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 28: 213-14(July 1962). (In English)

A thermodynamic analysis is given of the generation of cosmic radiation by ejection from an accelerating region (e.g., a nebula). The accelerating region is allowed to have a variable volume. Equipartition of energy between turbulent gases, magnetic fields, and cosmic particles is assumed in this region. (T.F.H.)

**11457** KOSMICHESKIE LUCHI BIBLIOGRAFICHESKII UKAZATEL 1956-1960. (Cosmic Rays; Bibliographic Guide, 1956-1960). Moscow, Publishing House of the Academy of Sciences, 1961. 194p.

A bibliographic guide with annotations was compiled for the period 1956 to 1960. The bibliographies are divided according to the subjects: the origin of cosmic rays, elementary particles, investigations of cosmic ray components, radiation belts, rockets and satellites, equipment and investigative methods, biological effects of cosmic rays, and effects of cosmic rays on geophysical and astrophysical phenomena. (R.V.J.)

## Criticality Studies

**11458** (HW-75887) EIGENVALUE MATRIX SOLUTION TO N-COMPONENT NEUTRON INTERACTION PROBLEMS. F. R. Czerniejewski (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Jan. 3, 1963. Contract AT(45-1)-1350. 18p.

The work previously reported by Czerniejewski (Physics Research Quarterly, January, February, March, 1962) on neutron interaction between two separated fissile units is extended to the general case of N components with various spacings and nuclear properties. An eigenvalue matrix theory of interaction is derived in terms of better defined physical quantities. Results are tabulated for identical interacting units in various arrangements. Errors result from assumptions in the calculation of the interaction parameters and the diffusion theory cross sections used. A simple method is also given for calculating systems of dissimilar units by assuming a linear form of $k(\alpha)$. Extension to arrays with outside reflector is possible. From comparison calculations it is evident that normal safety factors are meaningless with the uncertainty of 15 to 70% overconservative in $k_{eff}$. (L.T.W.)

**11459** (HW-SA-2432(Rev.)) CRITICAL MASS EXPERIMENTS WITH PLUTONIUM NITRATE SOLUTIONS. E. D. Clayton, R. C. Lloyd, and W. A. Reardon (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 23, 1962. Contract [AT(45-1)-1350]. 22p.

Criticality data obtained with a 14-in.-dia. stainless steel sphere filled with plutonium nitrate of various compositions and with various states of neutron reflection are presented. The data on the paraffin-reflected spheres were corrected for reflector savings and the experiments reduced to equivalent critical systems. The data were also corrected for acid molarity. (J.R.D.)

**11460** (TID-17633) CRITICAL INTERACTION POTENTIALS OF WATER MODERATED $UF_6$ ARRAYS. C. E. Newlon (Oak Ridge Gaseous Diffusion Plant, Tenn.). Jan. 18, 1963. Contract [W-7405-eng-26]. 7p.

It is noted that the critical spacings of individual subcritical units in large arrays may be computed by use of an interaction potential method based on the solid angle of neutron interaction. The method was written in a Fortran code for two- and three-dimensional arrays for use with the IBM-7090. Calculation results are included for nuclearly safe $UF_6$ cylinder arrays. (J.R.D.)

**11461** (TID-17817) INVESTIGATION OF FAST REACTOR SYSTEMS BY A ZONE TECHNIQUE. F. H. Helm

(Argonne National Lab., Ill.). Nov. 1962. Contract [W-31-109-eng-38]. 16p. (UAC-7073)

Calculations were made about two possibilities to determine critical dimensions for a given composition by zone loadings in a fast critical assembly. Both types of loading approximate a zero flux gradient vertical to the zone boundaries. Analytical expressions for flux distributions and critical conditions were found by two-group diffusion calculations. The results achieved in this way were, for some selected cases, compared to those found by more detailed machine calculations. Special consideration was given to the error which would be introduced by extrapolating values measured in zone criticals to full-sized cores. (auth)

**11462** (UCRL-6707) CRITICAL-SIZE CALCULATIONS FOR NEUTRON SYSTEMS BY THE MONTE CARLO METHOD. Donald H. Davis (California. Univ., Livermore. Lawrence Radiation Lab.). Dec. 12, 1961. Contract W-7405-eng-48. 27p.

A Monte Carlo calculation of the size and the neutron distribution in a critical system is described. Details including a flow diagram are given. Although the calculation is for a single-material spherical system, the extension to systems with complex geometry is not difficult. Two example calculations are given. The first is an ideal system in which the neutrons travel with a single velocity. The second is the calculation of the critical size and the leakage spectrum of the Godiva Critical Assembly. Calculation on the IBM 7090 computer takes a few minutes. (auth)

**11463** NUMERICAL AND GRAPHICAL METHOD OF THE REACTOR CRITICAL MASS CALCULATION IN CASE OF ANISOTROPIC DIFFUSION COEFFICIENT. Z. Szoda. Nukleonika, 7: 681-91(1962). (In Russian)

The method deals with the calculation of the critical mass of cylindrical nuclear reactors that can be described with sufficient precision by two grouped diffusion equations or so-called two and one-half grouped ones. The method takes into consideration the anisotropy of the diffusion coefficient and assures precision to three significant digits. (auth)

## Elementary Particles and Radiations

**11464** (AFOSR-2978) THE PRESENT STATUS OF THE NEW RESONANCES. Scientific Note No. 14. A. P. Balachandran and H. Pietschmann (Vienna. Universität. Institut für Theoretische Physik). May 30, 1962. Contract AF61(052)-265. 28p. (AD-278179)

The available experimental material on the resonances observed in systems of strongly interacting particles is presented. The report confines itself strictly to well-established facts and although references to the various phenomenological models proposed to understand these resonances are given, none of the conclusions reached purely from such models are included in the tables for these resonances. (auth)

**11465** (BNL-6646) A SIMPLE THEORY OF THE PROCESS $p + p \rightarrow d + \omega^+$. Preliminary Version. Jeremy Bernstein (Brookhaven National Lab., Upton, N. Y.). Aug. 1962. Contract [AT(30-2)-Gen-16]. 12p.

Mathematical work involved in a simple proposed theory for predicting omega mesons in association with deuterons by the process $p + p \rightarrow \omega^+ + d$ is shown. An expression for the total cross section is derived. (D.C.W.)

**11466** (CERN-62-33) FERMION REGGE POLES AND THE ASYMPTOTIC BEHAVIOUR OF BACKWARD MESON-NUCLEON SCATTERING. T. Kinoshita (European Organization for Nuclear Research, Geneva). Oct. 1962. 16p.

Gribov's findings on fermion Regge poles in the neighborhood of $u = 0$, where u is the square of the center-of-mass energy in the u channel, are confirmed; and the effect of fermion Regge poles of the u channel is examined by considering the case $u < 0$. An oscillation of the amplitudes due to the Regge poles at $u < 0$ is noted, and an abortive attempt is made to observe the oscillation in the differential cross section in the s channel. (D.C.W.)

**11467** (IKF-4) NACHWEIS DER ASSOZIIERTEN TEILCHEN BEI EINEM D-D-GASTARGET. (Detection of the Particles Associated with a D-D Gas Target). K. Debertin (Johann-Wolfgang-Goethe-Universität, Frankfurt am Main. Institut für Kernphysik). July 1962. 10p.

A D-D gas target is described by which the associated $He^3$ particles below 90° compared with the incident deuteron direction can be detected by a CsI(Tl) scintillation counter. The $He^3$ impulse can be discriminated from the disturbance impulses from various sources. (tr-auth)

**11468** (JINR-D-1108) ON DISPERSION RELATIONS IN QUANTUM ELECTRO-DYNAMICS. L. D. Solovev (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics). July 23, 1962. 8p.

A method of writing dispersion relations in quantum electrodynamics is considered. The proof is carried out in the lowest orders of perturbation theory improved by means of the renormalization group. (auth)

**11469** (JINR-E-1100) ON THE RADIATIVE CORRECTIONS IN THE NEUTRON DECAY. Van-hieu Nguyen and Ya. A. Smorodinskii (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics). Oct. 16, 1962. 5p.

In an examination of the influence of weak magnetism on neutron decay, it is shown that if the terms of the order $\alpha$ m/M are neglected then the radiative corrections to the neutron decay change only the values of the decay constants, but do not change the correlation or polarization decay properties. The cause lies in the $\gamma_5$-invariances of the theory in the considered approximation which forbids the variants S, T, and P. (auth)

**11470** (JINR-E-1116) INFRARED SINGULARITIES AND REGGE TRAJECTORIES IN ELECTRODYNAMICS. L. D. Solovev and O. A. Khrustalev (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics). Oct. 27, 1962. 6p.

The form of the Regge trajectory in the lowest order in $e^2$ for the relativistic charge particle interaction is obtained on the basis of the analysis of the infrared singularities in quantum electrodynamics. In the non-relativistic limit this trajectory corresponds to the bound states of the Coulomb potential. Generalization of the formulas to the case of particles with unequal masses is possible. (auth)

**11471** (JINR-E-1120) ON THE INTERPRETATION OF HIGH ENERGY NEUTRINO EXPERIMENTS. L. I. Lapidus (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). Nov. 12, 1962. 6p.

Experiments at Brookhaven with the high energy neutrino have established that the number of mesons ($\mu^+$) produced by neutrinos due to $\pi^+ \rightarrow \mu^+ + \nu(\nu^-)$ decay is greater than that of electrons. Examination reveals that a five-fold predominance is possible depending on the role of the induced pseudo-scalar in various processes. Comment on reaction cross sections is included. (D.C.W.)

**11472** (JINR-P-1046) ISPOL'ZOVANIE KONFORMNOGO OCTOBRAZHENIYA DLIYA EKSTRAPOLYATSII EKSPERIMENTAL'NO NABLYUDAEMYKH ZAVISIMOSTEI

V NEFIZICHESKUYU OBLAST. (Utilization of Conformal Representation for the Extrapolation into Non-Physical Areas of Experimentally Determined Relationships). Yu. M. Kazarinov, F. Legar, and I. N. Silin (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems and Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics). 1962. 11p.

The conformal representation was used for determining the coupling constant and the spectral functions of the nucleon-nucleon scattering amplitude. (auth)

**11473** (JINR-P-1071) O NEKOTORYKH REAKTSIYAKH PEREDACHI PRI OBLUCHENII TORIYA IONAMI $Ne^{22}$. (Transfer Reactions in Thorium Irradiation by $Ne^{22}$). G. Kumpf and E. D. Donets (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Reactions). 1962. 12p.

Reactions in which several (5 to 8) nucleons are transferred in heavy-ion collisions were studied. Targets of $Th^{232}$ were bombarded by $Ne^{22}$, and heavy $\alpha$-active products $Th^{227}$, $Ac^{226}$, $Ac^{225}$, and $Ac^{224}$ were detected. Formation cross sections of these isotopes were measured as functions of energy of bombarding particles. They increase monotonically beginning from $10^{-30}$ $cm^2$ at the Coulomb barrier to $10^{-27}$ $cm^2$ at energy 154 Mev. Angular distributions for recoil-nuclei of these isotopes at 150 and 120 Mev are reported. They have maximums near the Rutherford cutoff. The peaks are at different angles for the different isotopes. The more nucleons are transferred, the greater is the angle at which the peak occurs. The reported results do not fit into existing models for mechanism of transfer reactions. (auth)

**11474** (JINR-P-1079) O STATISTICHESKOM FONE RESONANSNYKH SOSTOYANII. (On Statistical Background of Resonant States). G. I. Kipylov (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of High Energy). 1962. 12p.

A formula is suggested that describes explicitly the influence of different factors on the statistical background of the resonances found by the effective mass of their decay products. The formula is useful in predicting qualitatively the form of the statistical background. The conditions are indicated under which false resonances are expected to appear. An experiment is proposed to check the assumptions about the form of the statistical background. (auth)

**11475** (JINR-P-1085) KONTROL EFFECTIVNOSTI NOBLYUDENII I OTSENKA ISTINNOGO CHISLA SOBYTII. (Efficiency Standards and an Estimate of the Virtual Number of Events). S. N. Sokolov and K. D. Tolstov (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics and Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of High Energy). Sept. 12, 1962. 11p.

The usual estimate of the total number of events based on two scans is shown to be misleading if the events are inhomogeneous with respect to the difficulty of their detection. An estimate based on three scans is derived which takes into account the principal part of the inhomogeneity. A general method for calculation of standard errors of any estimates expressable in terms of the number of events found in many-fold scans is also given. (auth)

**11476** (JINR-P-1111) REAKTSIYA $\pi + N \rightarrow \pi + \gamma +$ N I KONSTANTA FOTOROZHDENIYA $\pi$-MEZONA NA $\pi$-NEZONE. (The $\pi + N \rightarrow \pi + \gamma + N$ Reaction and the Constant of the Photoproduction of Pions on Pions). L. L. Nemenov (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1962. 6p.

The problem of determining the constant of the photoproduction of $\pi$ on $\pi$ from the analysis of the $\pi + N \rightarrow \pi + \gamma + N$ reaction is considered. The differential cross sections for this reaction are calculated in the pole approximation. (auth)

**11477** (LNF-62/94) CONSEQUENCES OF HIGHER SYMMETRY FOR ELECTRO MAGNETIC AND FOR WEAK TRANSITIONS. Note No. 164. R. Gatto (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). Nov. 19, 1962. 21p.

Higher symmetry schemes for electromagnetic and for weak transitions based on simple compact Lie groups of rank two are examined. Assignments of various particles to particular representations of the groups are shown as are weight diagrams and multiplication rules for the representations. Matrix elements for expression of electromagnetic form factors are discussed for a few models, and an attempt is made to extend the treatment to weak interactions. (D.C.W.)

**11478** (LNF-62/97) THE TWO NEUTRINOS. Note No. 167. R. Gatto (Italy. Comitato Nazionale per L'Energia Nucleare. Laboratori Nazionali, Frascati). Nov. 30, 1962. 40p.

Two hypotheses for elastic cross sections of neutrino reactions are examined. The two differ in assumptions made on the components of the weak (strangeness-conserving) current that couples the neutrino and the resultant lepton. Polarization in such scattering is discussed as is the effect of the Pauli principle on the cross section for scattering on a complex nuclei. Inelastic cross sections are treated also, and a few are calculated. An argument that leads to a proposal for the existence of two neutrinos and a multiplicative conservation law that forbids transformations of mesons($\mu$) into electrons is also presented for meson($\mu$)-electron symmetry, and existence of an additive conservation law is explored. Other symmetries, particularly higher symmetry schemes for leptons, are also treated. (D.C.W.)

**11479** (LNF-62/98) CLASSIFICATION OF LEPTON CURRENTS. Note No. 168. R. Gatto (Italy. Comitato Nazionale per l'Energie Nucleare. Laboratori Nazionali, Frascati). Nov. 27, 1962. 34p.

A description is used in which the neutrino is four-component, the positive muon, the negative electron, and the neutrino are called leptons, and leptons are conserved. Unitary transformations ($SU_3$) are performed on the three variables $\mu$, $\nu$, and e to classify particles and currents, leading to independent sets of currents that have either a definite parity or chiral character. Those with definite chiral character are physically acceptable and imply that the positive helicity leptons transform under $SU_3$ contragradiently with respect to the negative helicity leptons. The transformation properties allow the assignment of quantum numbers similar to strangeness and isotopic spin. A baryon lepton symmetry is formulated implying that positive helicity leptons correspond to p, n, and Z (baryon with S = −3) and negative helicity leptons correspond to $X^+$ (baryon with S = 1), $\Xi^0$, and $\Xi^-$. The weak four-lepton Lagrangian is written in a form invariant under lepton isospin transformations ($SU_2$) and physical consequences are discussed. Invariant four-fermion Lagrangians, quantum number assignments to leptons and currents currents, and currents themselves are given in tables. (auth)

**11480** (LNF-62/109) MUON CAPTURE IN HYDROGEN. Note No. 176. A. Fujii (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). Dec. 20, 1962. 11p.

The rate of meson ($\mu^-$) capture by protons according to

$\mu^- + p \rightarrow n + \nu$ is estimated within the framework of V-A theory and compared with the experimental capture rate in liquid hydrogen. The theoretical rate is seen to be higher than the experimental rate, and an attempt is made to explain the source of the difference. Tables display capture rates for various form factors and parameters. (D.C.W.)

**11481** (NP-12435(Pt.I)) MANY-BODY PROBLEMS. Lecture Given by G. E. Brown at Universitetets Institut for Teoretisk Fysik and NORDITA Copenhagen. (Nordisk Institut for Teoretisk Atomfysik, Copenhagen). Nov. 1961. 173p.

The Hartree method and the Hartree-Fock method for calculating wave functions in self-consistent fields are discussed, and use of occupation number representation is explained. Hartree-Fock equations are used in calculations of matrix elements using a Yukawa force in a liquid drop model nucleus. Perturbation theory is developed, particularly the Brillouin-Wigner and Rayleigh-Schrödinger perturbation expansions. Graphical techniques introduced into field theory by Goldstone and Hugenholtz as well as use of Wick's theorem in graphically analyzing series are examined. Various graphs are considered, and the effect of the Hartree-Fock self-consistent potential on graphs is explored. Brueckner's theory taking into account strong short-range nucleon repulsions is treated, and the one-particle Green's function described and calculated by graphical perturbation methods is extended to quasiparticles. Particle-hole excitations are examined, and the two-body Green's Function is introduced to describe particle-hole propagation. Particle-hole theory is then applied to liquid helium-3, and examination of collective motion in nuclei is undertaken with vibrations of the closed shells in spherical nuclei receiving particular attention. An extended schematic model for vibrations is described as is a time-dependent Hartree-Fock treatment for ground state solutions. Stability conditions in wave functions, moment of inertia considerations, and quantization of translational and rotational motion are other aspects discussed. (D.C.W.)

**11482** (NP-12435(Pt.II)) MANY-BODY PROBLEMS. [PART] II. Lecture Given by G. E. Brown at Universitetets Institut for Teoretisk Fysik and NORDITA Copenhagen. (Nordisk Institut for Teoretisk Atomfysik, Copenhagen). Sept. 1962. 69p.

A short history of pairing phenomena precedes analytical mathematical treatment of a degenerate model that is also solved in quasispin formalism. A more general system with two unperturbed levels is treated, and a quasiparticle method for solving the hamiltonian is applied to the degenerate case. The nondegenerate case is solved by Hartree-Fock treatment. Quasiparticle excitations, effect on moment of inertia of pairing (moment of inertia decreases), and vibrations in paired nuclei are included in the study. The role of phonons in superconductivity is introduced, and the Debye theory of specific heat is included to provide a model with which to handle phonons. Finally, theory of electron-phonon and electron-electron interactions in superconductivity is presented. (D.C.W.)

**11483** (NP-12436) ANALYTIC PROPERTIES OF THE S-MATRIX IN PERTURBATION THEORY. Lecture Given by R. E. Cutkosky at Universitetets Institut for Teoretisk Fysik and NORDITA Copenhagen. Notes Prepared by J. Kalckar and A. Reitan. (Nordisk Institut for Teoretisk Atomfysik, Copenhagen). July 1962. 142p.

Mandelstam's method for dealing with the S-matrix used to find from the in-state of incoming beams of wave packets the out-components observed after interactions is discussed. Generalizations of the method are discussed as well as some of its applications. Two versions of the crossing symmetry that play an important part in S-matrix application are presented, the Mandelstam diagram being shown to illustrate crossing symmetry. Singularities of the scattering amplitude in perturbation theory are also examined, and solutions of the Landu-Bjorken equation are shown to give the isolated singularities of finite ordered graphs. Examples of reduced graphs associated with these singularities are presented as are plausibility arguments. Treatment is also extended to cover particles with spin; and third and fourth order graphs are examined, the results of the study being applied to a few physical problems. Some aspects of the partial wave expansion as related to dispersion theory techniques are also discussed. (D.C.W.)

**11484** (NP-12460) ANGULAR DISTRIBUTION OF THE PRODUCTS OF THE $K_{e3}$ MESONIC DECAY. Technical Report No. 32. Paul E. Condon (Princeton Univ., N. J. Palmer Physical Lab. and Princeton Univ., N. J. Naval Ordnance Lab.). Dec. 15, 1962. Contract Nonr-1858(06). 89p.

Angular distribution of decay products of the reaction $K^+ \rightarrow e^+ + \nu + \pi^0$ is studied. Discussion of necessary calculations, experimental arrangement, design of the K meson beam, electronic circuits, and adjustment of equipment is included. Results are tabulated, and diagrams of various pieces of equipment are given. (D.C.W.)

**11485** (NP-12478) INFLUENCE OF THE SPIN ON THE POSITION OF REGGE POLES. Ya. I. Azimov (Akademiya Nauk S.S.S.R. Institut Teoreticheskoĭ i Eksperimental'noĭ Fiziki). 1962. 8p.

An influence of spin is considered on the position of condensations of Regge poles, which have been discovered by Gribov and Pomeranchuk. It is shown that the threshold condensations can be placed arbitrarily far to the right in the complex plane of total angular momentum. This means that the amplitude has an essential singularity at large energy and momentum transfer. The possibility of the existence of condensations that take place at any energy near the non-negative integer points is considered. (auth)

**11486** (NP-12479) ON THE REMOVING OF THE "GHOST" ON THE VACUUM REGGE POLE TRAJECTORY. V. B. Berestetskii (Berestetsky) (Akademiya Nauk S.S.S.R. Institut Teoreticheskoi i Eksperimental'noi Fiziki). 1962. 10p.

Gell-Mann's conclusion that one of the nucleon-nucleon scattering amplitudes still goes to infinity at $t = t_0$ is shown to be incorrect, and it is demonstrated that his primary supposition gives the finiteness of all the amplitudes even in the "ghost" region. (D.C.W.)

**11487** (NP-12488) ON THE PRODUCTION AND SPIN OF THE K* RESONANCE. S. W. MacDowell (Rio de Janeiro. Centro Brasileiro de Pesquisas Fisicas); A. L. L. Videira, and N. Zagury (Rio de Janeiro. Centro Brasileiro de Pesquisas Fisicas and Brazil. Universidade, Rio de Janeiro. Faculdade Nacional de Filosofia). Nov. 6, 1961. 13p. (Notas de Fisica, Vol. III, No. 12 (p.197-207)).

A summary of results from investigations of the production of the K* resonance in the reactions $K^- + p \rightarrow K^{*-} + p$, $K^{*-} \rightarrow \bar{K}^0 + \pi^-$ or $\bar{K} + \pi^0$ and $K^- + p \rightarrow \bar{K}^{*0} + n$, $\bar{K}^{*0} \rightarrow K^- + \pi^+$ precedes calculations of the total cross sections and angular correlations for the two reactions. The spin of K* is also examined. (D.C.W.)

**11488** (NP-12499) ON THE DECAY $\Sigma^0 \rightarrow \Lambda^0 + \gamma$ IN THE CHARGE-INDEPENDENT PION INTERACTION. Prem P. Srivastava (Rio de Janeiro. Centro Brasileiro

de Pesquisas Fisicas). Sept. 1, 1962. 8p. (Notas de Fisica, Vol. X, No. 3 (p.23-9)).

The anomalous $\Sigma^0 - \Lambda^0$ magnetic moment is calculated in the charge independent pion-baryon interaction. The lifetime for the radiative decay $\Sigma^0 \rightarrow \Lambda^0 + \gamma$ is found to be about $1.46 \times 10^{-18}$ sec for the same $\Sigma^0 - \Lambda^0$ parity, while it is about $0.33 \times 10^{-18}$ sec for the case of opposite parity. (auth)

**11489** (ORNL-3367) NUCLEON-MESON CASCADE CALCULATIONS: THE STAR DENSITY PRODUCED BY A 24-Gev PROTON BEAM IN HEAVY CONCRETE. R. G. Alsmiller, Jr., and J. E. Murphy (Oak Ridge National Lab., Tenn.). Jan. 21, 1963. Contract W-7405-eng-26. 22p.

The nuclear star density produced by a 24-Bev proton beam in a material having approximately the properties of heavy concrete is calculated. A comparison is made with experimental measurements made at CERN; but, since the quantity that can be calculated is not the same as that measured, no firm conclusions can be drawn. Proton, neutron, pion, and muon intensities are plotted vs. distance as are star densities. (auth)

**11490** (RM-3221-PR) UNIQUENESS PROBLEMS IN THE MATHEMATICS OF MULTIPLE SCATTERING. T. W. Mullikin (RAND Corp., Santa Monica, Calif.). June 1962. Contract AF49(638)-700. 9p. (AD-278263)

Some recent mathematical studies concerning the uniqueness of solutions to Chandrasekhar's mathematical formulation of principles of invariance in the theory of radiative transfer are reported. It is shown that the X and Y equations and the $\Psi_1^m$ and $\phi_1^m$ equations of Chandrasekhar have a multiplicity of solutions for many phase functions describing local scattering, the extent of the nonuniqueness having been only partially explored by Chandrasekhar. The present results should be of interest and concern to those attempting to solve these equations by numerical iteration. (auth)

**11491** (TID-15930) VECTOR MESONS AND NUCLEON-NUCLEON SPIN-ORBIT INTERACTION. G. Breit (Yale Univ., New Haven). [May 28, 1962]. Contract [AT(30-1)-1807). 6p.

Formulas connected with nucleon-nucleon spin-orbit interactions are reexamined due to increased interest in the possibility of a common origin for the nucleon-nucleon spin-orbit potential and a repulsive core potential suggested by the saturation of nuclear forces in a vector meson field interaction. Experiment is noted to give no clear indication of the presence of the spin-orbit potential, and theoretical uncertainties involved are examined. (D.C.W.)

**11492** (TID-16044) A NEW APPROXIMATION IN SCATTERING THEORY. K. R. Greider (Yale Univ., New Haven). [June 14, 1962]. Contract [AT(30-1)-1807]. 10p.

A new approximation that is useful in treating scattering problems in which one or more of the potentials is of long range is described. The method is similar to Chew and Wick's impulse approximation in that it permits treatment of the scattering of a particle by multiple potentials in terms of the physical t-matrices for the separate two-body interactions. The method is applied to the neutron transfer process in low energy ion-ion scattering and the high energy (p,d) pickup reaction. The results agree well with experimental results for the two processes. (D.C.W.)

**11493** (TID-16216) POSSIBLE INTERPRETATIONS OF HIGH-ENERGY CROSS SECTIONS. K. Tanaka (Argonne National Lab., Ill.). May 2, 1962. Contract [W-31-109-eng-38]. 5p. (UAC-6400)

Total cross sections for K meson-nucleon and nucleon-nucleon scattering at high energy are examined in terms of hypotheses of generalized isospin independence and of Regge poles. A description of the K meson-nucleon system that can be extended to the nucleon-nucleon system to find possible Regge poles is given, and the effects of the Regge poles are commented upon. (D.C.W.)

**11494** (TID-17627) PROTONS FROM 50 Mev TO 12.5 Bev. John H. Martin (Argonne National Lab., Ill.). Oct. 18, 1962. Contract [W-31-109-eng-38]. 12p.

A tabulation of equipment to be used in increasing the energy of orbiting protons in the Argonne ZGS from 50 Mev to about 12.5 Bev is given. Also included is information on the equipment that will read the performance of the orbiting protons. (D.C.W.)

**11495** (TID-17731) THE PROBLEM OF BRANCH POINT TRAJECTORIES IN THE COMPLEX ANGULAR MOMENTUM PLANE. Reinhard Oehme (Chicago. Univ. Enrico Fermi Inst. for Nuclear Studies and Chicago. Univ.). Dec. 1962. Contract AT(11-1)-264. 10p.

It is shown that the interpolating partial wave amplitude $F(s,\lambda)$ has $\lambda$-independent branch points in the s-plane corresponding to all physical thresholds, including those involving particles that are members of Regge trajectories. On the basis of this fact an argument is given that indicates that there are no moving branch points associated with three-particle thresholds, and that makes it plausible that there may also be none connected with higher thresholds. It is shown briefly that possible moving branch points could not disappear from the physical sheet of the energy plane through two-particle thresholds or through left-hand cuts. (auth)

**11496** (TID-17742) NEW MESONS AND RESONANCES IN STRONG INTERACTION PHYSICS — THEORETICAL. J. J. Sakurai (Chicago. Univ. Enrico Fermi Inst. for Nuclear Studies and Chicago. Univ.). [1962]. Contract [AT(11-1)-264]. 60p.

Discussion of the Yukawa concept and its triumphs and failures in explaining phenomena in strong reaction physics precedes treatment of the vector theory of strong interactions that succeeded in predicting several particles since observed. The role of vector mesons is examined, and the universality of vector couplings is treated. The $\rho$ decay is given particular treatment as is s-wave $\pi$-N scattering. Meson($\rho$) decay and $\pi$-N scattering are observed to agree with the universality principle. Several decay modes of the omega meson are investigated as are methods for measuring the rate of the decay modes. Unitary symmetry models based on several multiplets are demonstrated, and interactions in the models are examined. (D.C.W.)

**11497** (UCRL-6450-T(Rev.I)) EQUATION OF STATE OF CLASSICAL SYSTEMS OF CHARGED PARTICLES. S. G. Brush, H. E. DeWitt, and J. G. Trulio (California. Univ., Livermore. Lawrence Radiation Lab.). [1961?] Contract [W-7405-eng-48]. 44p.

Recent developments in the classical theory of fully ionized gases and strong electrolyte solutions are reviewed, and are used to discuss the equation of state at high temperatures and low densities. The pressure is calculated using the ring-integral approximation, and quantitative estimates of higher correction terms are given. The effect of short-range repulsive forces is shown by comparing the results with two kinds of potential functions: hard spheres of diameter a, and "soft" spheres for which the short-range potential cancels the Coulomb potential at the origin and decreases exponentially with distance. It is

found that the use of either type of potential extends the range of validity of the ring integral approximation to considerably higher densities and lower temperatures. Since there is little difference in the results for the hard spheres and the soft spheres in this range, the latter is investigated more extensively since it is more easily handled by analytical methods. The expressions derived for the free energy of a system of charged particles can also be used in ionization equilibrium calculations, and the effect of electrostatic interactions on the equilibrium concentrations of various kinds of ions is indicated. 56 references. (auth)

**11498** (UCRL-10028) THEORY OF NUCLEON-NUCLEON SCATTERING IN THE STRIP APPROXIMATION TO THE MANDELSTAM REPRESENTATION. John M. Charap (California. Univ., Berkeley. Lawrence Radiation Lab.); Elihu Lubkin (Brown Univ., Providence); and Antonio Scotti (California. Univ., La Jolla). Dec. 19, 1961. Contract W-7405-eng-48. 139p.

The nucleon-nucleon scattering amplitude is discussed within the framework of the strip approximation. Asymptotic bounds to the behavior of the amplitudes are derived and are applied to limit the number of allowed single spectral functions to six and correspondingly to limit the types of dynamically independent one-particle states. In particular, it is found that the pion is in this sense allowed, while the deuteron is not. The unitarity equations, in which only two-particle intercalated states are retained, are explicitly derived in both the N-N and N-$\bar{N}$ channels. The N-$\bar{N}$ equations express a portion of the double spectral functions in terms of the $\pi$-N amplitudes; the N-N equations express another portion of these functions through coupled integral equations. (auth)

**11499** (UCRL-10089(Rev.)) SEARCH FOR A FOUR-PION RESONANCE, AND SOME DECAY MODES OF THE $\rho$ AND $\omega$ MESONS. Nguyen-Huu Xuong and Gerald R. Lynch (California. Univ., Berkeley. Lawrence Radiation Lab.). Feb. 12, 1962. Contract W-7405-eng-48. 15p.

Various decay modes of mesons, particularly the $\rho$ and $\omega$, are discussed in view of the possibility that their decay might lead to four-pion resonances. Spin and parity of a few mesons are also discussed, and the $\omega$ meson is concluded to have spin and parity $1^{-2}$. (D.C.W.)

**11500** (UCRL-10118(Rev.)) THE MEAN LIFE OF THE NEUTRAL PI MESON. Hla Shwe, Frances M. Smith, and Walter H. Barkas (California. Univ., Berkeley. Lawrence Radiation Lab.). May 28, 1962. Contract W-7405-eng-48. 42p.

An experiment to measure the $\pi^0$ mean life, using a new method that utilizes the relativistic flight-path dilation produced by a high pion velocity is reported. A negative pi meson beam of 3.5 Bev/c interacts in Ilford K.5 emulsion. Some 103 secondary $\pi^0$ are observed to decay by the Dalitz mode ($\pi^0 \rightarrow e^+ + e^- + \gamma$) in a study of 3600 such stars. The $\pi^0$ path lengths can be accurately measured and are automatically calculated by specially developed equipment. The $\pi^0$ momentum spectrum is assumed to be the same as that of the secondary charged pions found by multiple scattering measurements. The mean transverse momentum of secondary charged pions at all angles is 274 ± 10 Mev/c. The opening-angle distribution of the electron pairs is measured and compared with extensive calculations of the expected laboratory-system distribution in order to evaluate the number of unobserved events. A statistical approach is used to evaluate the mean life ($\tau_{\pi^0}$) of the $\pi^0$. The maximum-likelihood estimate is $\tau_{\pi^0} = 2.0 \times 10^{-16}$ sec. The residual effect of systematic errors is thought to be small. The observed Dalitz pairs are listed. 32 references. (auth)

**11501** (UCRL-10209) ON COMPLEX ANGULAR MOMENTUM IN MANY-CHANNEL POTENTIAL-SCATTERING PROBLEMS. [PART] II. John M. Charap and Euan J. Squires (California Univ., Berkeley. Lawrence Radiation Lab.). May 3, 1962. Contract W-7405-eng-48. 40p.

It is shown that for many-channel, arbitrary spin, potential-scattering problems, the previously defined continuation of the S matrix to nonphysical values of total angular momentum is such that a generalized Sommerfeld-Watson transformation on the partial-wave expansions of the scattering amplitudes can be made. An important symmetry of the partial-wave amplitudes is obtained, thus permitting an analogue of Mandelstam's modification of the Sommerfeld-Watson transform. It is shown that a pole of the S matrix at $J = \alpha$ is associated with a contribution to the scattering amplitude that behaves like $z^\alpha$ for large values of $z = \cos\theta$, $\theta$ being the scattering angle, and that such contributions dominate over the remaining integral terms. Exchange potentials and the generalization of J-parity are discussed, and some results on the positions of poles of the S matrix are derived. (auth)

**11502** (WAPD-T-1458) APPLICATION OF THE SPHERICAL HARMONICS TECHNIQUE TO PROBLEMS IN GAMMA TRANSPORT. W. D. Lanning (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). June 1962. Contract AT(11-1)-Gen-14. 34p.

The feasibility of applying the spherical harmonics technique to problems in gamma transport is investigated. The spherical harmonics procedure is described for one-dimensional slab geometry for plane monoenergetic sources. Energy spectra obtained by the P-3 approximation covering a wide range of source energies and materials are compared to moments results for penetrations up to fifteen mean free paths. The comparisons indicate that it is plausible to extend the method to multi-slab geometry for potential design applications. (auth)

**11503** ELECTROMAGNETIC SIMULATION OF POINT GAMMA SOURCES. E. Beynam. Atomkernenergie, 7: 369-70(Oct. 1962). (In German)

The electromagnetic field and the flux field of gamma rays are mathematically coupled, and the calculation possibilities resulting are discussed by way of examples and by including the source motion. (auth)

**11504** SOLUTIONS IN SPHERICAL COORDINATES OF GENERAL EQUATIONS OF PARTICLES WITH SPIN. André Jolivet (Institut Henri Poincaré, Paris). Compt. Rend., 255: 2055-7(Oct. 22, 1962). (In French)

The wave functions in spherical coordinates were determined in the case of particles with any spin by utilizing a representation allowing these functions to be expressed by simple formulas. (tr-auth)

**11505** ELASTIC ELECTRON-DEUTERON SCATTERING WITH LOW TRANSFER MOMENTUM AND THE ELECTROMAGNETIC STRUCTURE OF THE NEUTRON. Bernard Grossetête, Daniel Treille, and Pierre Lehmann (Laboratoire de l'Accelerateur Lineaire, Orsay, France). Compt. Rend., 255: 2089-91(Oct. 22, 1962). (In French)

The electron-deuteron elastic scattering cross section was measured for an energy transfer momentum equal to 1 fermi$^{-1}$ and for three angles (60, 90, and 130°). The results were analyzed with the aid of recent Glendenning and Kramer calculations in order to deduce the neutron form factors. (tr-auth)

**11506** ELASTIC ELECTRON-PROTON SCATTERING WITH WEAK TRANSFERS. Boris Dudelzak, Gilles Sauvage, and Pierre Lehmann (Laboratoire de l'Accélérateur Linéaire, Orsay, France). Compt. Rend., 255: 2250-2(Oct. 29, 1962). (In French)

A study was made to determine the form factors of protons for low transfers. A value was deduced for the proton mean square radius and compared with some theoretical predictions. (tr-auth)

**11507** ELASTIC INTERACTIONS OF HIGH ENERGY PARTICLES. V. S. Barashenkov (Joint Inst. for Nuclear Research, Dubna, USSR). Fortschr. Physik, 10: 205-69 (1962). (In English)

The experimental and theoretical data pertaining to the elastic scattering of strongly-interacting particles, such as $\pi$ and K mesons, nucleons, and antinucleons are considered in detail. The study is limited to the high energy interactions when the de Broglie wave lengths are some times shorter than the geometric dimensions of the interacting particles. 103 references. (J.S.R.)

**11508** THE CINI-TOUSCHEK-TRANSFORMATION FOR DIRAC PARTICLES IN EXTERNAL FIELDS. H. Hogasen. Kgl. Norske Videnskab. Selskabs, Forh., 34: 54-9(1961). (In English)

The Cini-Touschek (Nuovo Cimento 7: 422(1958)) transformation of the free-particle Dirac equation is considered. It is shown that this transformation may also be extended to the case of interactions of spin-$\frac{1}{2}$ particles with external fields. The properties of the scattering amplitude for this type of interaction are derived. (T.F.H.)

**11509** THE ERIKSEN TRANSFORMATION IN THE CASE OF PARTICLES WITH SPIN 0 AND 1. H. Hoegasen. Kgl. Norske Videnskab. Selskabs, Forh., 34: 60-5(1961). (In English)

The formal procedure for obtaining the Foldy-Wouthuysen (Phys. Rev. 78: 23(1950)) representation for fermions is considered. A transformational procedure is discussed that gives in closed form a transformation to two-component theory with separated positive energies in the general case of time-dependent external fields, and it is shown that this transformational procedure can be extended to include the cases of spins 0 and 1. The results of this investigation are used to study the scattering of vector mesons. (T.F.H.)

**11510** INFLUENCE OF ANHARMONISM ON THE ENERGY DISTRIBUTION OF INELASTICALLY SCATTERED NEUTRONS. II. FOURPHONON INTERACTION. V. Kashcheev (Inst. for Physics, Academy of Sciences, Latvian SSR). Latvijas PSR Zinatnu Akad. Vestis, No. 5, 67-73 (1962). (In Russian)

The widening and shift in the frequency of the one-phonon coherent nuclear scattering of slow monochromatic neutrons in crystals caused by anharmonic vibrations was examined. In particular, the influence of the phonon wave vector and the temperature on the widening and frequency shift arising from the four-phonon interaction of acoustical phonons was studied. A Hamiltonian was derived for the crystal scatterer which takes into account the four-phonon interaction. The damping-out of phonons is discussed as well as the correction that enters into their frequencies. It is pointed out that the three- and four-phonon interaction effects are additive if the operators $H_3 + H_4$ are placed in the Hamiltonian. (TTT)

**11511** ON THE THEORY OF MAGNETIC SCATTERING OF NEUTRONS FROM IMPURITY CENTERS IN CRYSTALS. V. Kashcheev (Inst. for Physics, Academy of Sciences, Latvian SSR). Latvijas PSR Zinatnu Akad. Vestis, No. 7, 53-6 (1962). (In Russian)

The magnetic scattering of nonpolarized slow neutrons by a single impurity center in a crystal was investigated. This scattering is accompanied by the transition of the impurity center from an electronic state 1 to a state 2. The phonon-electronic interaction was assumed to be adiabatic and a formula was derived for the differential scattering cross section. The cross section was evaluated using a "detailed" wave function for the description of the state of the center. The value for the differential cross section was found to be about $10^{-4}$ to $10^{-5}$ barns/sterad, i.e., a number comparable in magnitude to nuclear scattering cross sections from the impurity center. Further, the case of nonadiabatic conditions was considered, where there is a weak coupling between the center's electrons and the lattice vibrations. A formula was derived that gives the temperature dependence of the cross section. For high temperatures this dependence is linear; for low temperatures the cross section is proportional to exp (-hw/kT), where w is the frequency, T the temperature, and h and k are Planck's and Boltzman's constants, respectively. (TTT)

**11512** THE DECAY OF $K^-$ MESIC ATOMS. J. R. Rook (Oxford Univ.). Nucl. Phys., 39: 479-505(Dec. 1962). (In English)

In the first part of this paper we examine the information concerning the form of the nuclear density distribution in the extreme surface region that would be obtained from measurements of the $K^-$ mesic x ray yields. It is concluded that certain extreme shapes would be distinguished from the conventional Saxon-Woods form, but there is not as much sensitivity to the form of the density distribution as might be expected. Reasons are given for this lack of sensitivity. In the second part we discuss the significance of the relatively large number of multinucleon events observed in nuclear emulsion. The discrepancy between the deuterium and emulsion data is first established and then the probability for the "two step" process suggested by McCarthy is calculated. It is concluded that this process does not explain the frequency of multi-nucleon events observed in nuclear emulsion and it appears that there is some support for the hypothesis of strong correlations in the nuclear surface. (auth)

**11513** ON THE STRUCTURE OF THE THREE-PARTICLE SCATTERING OPERATOR IN CLASSICAL GASES. P. Resibois (Universite Libre, Brussels). Phys. Letters, 2: 60-1(Aug. 15, 1962) (In English)

It has been demonstrated that an expression for the asymptotic collision operator for any n-particle collision process can be reduced to the well-known form of the Boltzmann operator in the case of a three particle collision. An exact equivalence between an expression for the scattering operator in spatially homogeneous situations and the asymptotic collision operator has also been demonstrated. As far as the asymptotic collision operator is concerned the present work establishes the link between the different approaches proposed in recent years for tackling the problem of irreversible statistical mechanics. (H.D.R.)

**11514** CONSIDERATIONS OF THE DYNAMIC SINGULARITY IN THE $\bar{K}N$ SCATTERING AMPLITUDE AND THE $Y_0^*$. San Fu Tuan (Brown Univ., Providence, R. I.). Phys. Letters, 2: 62-5(Aug. 15, 1962). (In English)

Recent experimental studies of the reaction $\pi^- + p \rightarrow K + \Sigma + \pi$ at 2.1 Bev/c indicate the $Y_0^*$ is strongly produced, and the distribution of Dalitz-plot events in the region of the peak suggests the $Y_0^*$ may be identified with a theoretically predicted bound S-state of the $\bar{K}$-N system. From a theoretical point of view, the strength and location of the dynamical singularity branch-cut due to the $K + \bar{K} \rightarrow N + \bar{N}$ proc-

ess and its contribution to the $\bar{K}$-N scattering amplitude are naturally of relevance in influencing the prediction of $Y_0^*$ on the basis of the zero-range approximation. A qualitative discussion is presented on some of the features of this dynamical singularity. (H.D.R.)

**11515** TREIMAN-YANG CRITERION AND PERIPHERAL NUCLEON-NUCLEON COLLISIONS. E. Ferrari (CERN, Geneva). Phys. Letters, 2: 66-8(Aug. 15, 1962). (In English)

Treiman and Yang have proposed that the hypothesis of the dominance of the peripheral (one-pion exchange) mechanism of interaction is subject to a very simple experimental test, valid also in the presence of any "structure" of the interaction of the virtual intermediate pion with the production in nucleon-nucleon collisions is examined. (H.D.R.)

**11516** PAIR-PRODUCTION CROSS-SECTIONS FOR PHOTONS BOMBARDING PROTONS AT HIGH ENERGIES. W. Ruhl (Universität, Cologne). Phys. Letters, 2: 69-70 (Aug.15, 1962). (In English)

Calculations are described for obtaining a formula for the total cross section for the production of electron-positron pairs in an energy range above the proton rest energy. Only the diagrams that contribute to the Bethe-Heitler formula are considered, and a form-factor that corresponds to an exponential charge and moment distribution in the nonrelativistic limit is applied. The result of the calculation is the Bethe-Heitler formula independent of the form factor used, which is seen to wholly describe the total pair-production cross section in the field of a protron except for the VC-part. (H.D.R.)

**11517** A FURTHER NOTE ON THE POLES OF GREEN FUNCTIONS. D. Ter Haar and W. E. Parry (Clarendon Lab., Oxford). Phys. Letters, 2: 70(Aug. 15, 1962). (In English)

A correction and brief note of clarification is presented in regard to a recent letter on the poles of Green functions and excitation energies. (H.D.R.)

**11518** PION-PION AMPLITUDES FROM LOW ENERGY PION-PRODUCTION. W. Zoellner (CERN, Geneva). Phys. Letters, 2: 72-3(Aug. 15, 1962). (In English)

The amplitudes of the process $\pi + N \rightarrow 2\pi + N$ are approximately summing all one-particle states (six nucleon-poles and one pion-pole) and allowing for the influence of more-particle states by reducing the obtained cross sections by 25%. Theoretical cross sections, including the $\pi$-pole contributions, are adapted to the experimental cross sections of the reactions $\pi^+ + p \rightarrow 2\pi + N$ to yield $\pi$-$\pi$ amplitudes. Results are compared to results from previous experimental and theoretical investigations. (H.D.R.)

**11519** A CONSISTENTLY RELATIVISTICALLY INVARIANT FORMULATION OF THE QUANTISED PROBABILITY-AMPLITUDE FIELD THEORY. Yu. M. Lomsadze, I. Yu. Krivskii, and I. V. Khimitch (Uzhgorod State Univ., Ukrainian SSR). Phys. Letters, 2: 80-1(Aug. 15, 1962). (In English)

A new quantum theory, the quantized probability-amplitude field theory, has been constructed by quantizing the state vector $\Phi[N(k); t]$ of the conventional quantized field system. The essential addition in the new theory is the concept of the "inside chaotic state" of $\iota$, necessarily different eigenstates leading to the G-state. It is shown that the complete construction of the quantized probability-amplitude field theory may be carried out in a manifestly relativistically invariant form from the beginning. (H.D.R.)

**11520** A PRINCIPLE OF INVARIANCE UNDER INVERSION FOR EACH CONSTANT IN THE THEORY AND ITS CONSEQUENCES. V. I. Kushtan, Yu. M. Lomsadze, and G. D. Romanko (Uzhgored State Univ., Ukrainian SSR). Phys. Letters, 2: 82-3(Aug. 15, 1962). (In English)

The total Lagrangian of the quantized field theory contains different bare constants: the coupling constants and the rest masses of particles. The possibility arises that the choice of the signs of these constants is inessential, that is, that the theory must be invariant under the groups of the inversions of each constant entering into the theory. To realize this, the field operators must be transformed by some non-trivial representation of the groups of these inversion. The method for realizing this concept is shown, and the physical consequences of the concept are discussed. (H.D.R.)

**11521** COMPLEX ANGULAR MOMENTUM IN RELATIVISTIC DISPERSION THEORY. R. Oehme and G. Tiktopoulos (Univ. of Chicago). Phys. Letters, 2: 86-8(Aug. 15, 1962). (EFINS-62-35) (In English)

Discussed are the singularities of relativistic partial wave scattering amplitudes in the complex angular momentum plane. It is shown that, for points in the finite plane, these singularities are determined by the high energy limits of the absorption parts in the two crossed channels. The analytic properties of the pole trajectories and the residues are examined. These functions are shown to have no left-hand branch points, which are present in the S-plane of the partial wave amplitudes $F_s(S,\lambda)$, where S is the energy variable and $\lambda$ is the angular momentum variable. The functions $F_s(S,\lambda)$ are seen to have left-hand branch points in S that are not present in the physical partial wave amplitude F(S,l). (H.D.R.)

**11522** HIGHER ORDER WEAK INTERACTIONS AND THE $(K_1^0 - K_2^0)$ MASS DIFFERENCE. S. K. Bose (Univ. of Rochester, N. Y.). Phys. Letters, 2: 92-3(Aug. 15, 1962). (In English)

The self-energies associated with one particle intermediate states in the $K_1^0$ and $K_2^0$ propagators are considered as a simple mechanism whereby the second order weak interactions could generate the $(K_1^0 - K_2^0)$ mass difference. Weak vertices of the type $K \rightarrow \pi$ are considered and required to satisfy CP invariance. If intermediate states with more than one particle are ignored, the $K_1^0$, and self-masses can be calculated from the relevant pole diagrams. (H.D.R.)

**11523** EVIDENCE FOR THE RADIOACTIVE DECAY MODE $K^+ \rightarrow \pi^+ + \pi^+ + \pi^- + \gamma$. W. Puschel (Max-Planck-Institut für Physik und Astrophysik, Munich), J. Tietge, D. Monti, G. Giacomelli, and A. Quareni Vignudelli. Phys. Letters, 2: 96-8(Aug. 15, 1962). (In English)

The radiative $\tau$-decays of $K^+$ mesons were studied by exposing emulsion stacks to a 700 Mev/c $K^+$ beam. The interpretation of the events in terms of range and energy measurements on all $\pi$ mesons and the momentum carried away by a neutral particle indicates three cases of $K^+ \rightarrow \pi^+ + \pi^+ + \pi^- + \gamma$ decay. The experimental value of the branching ratio is concluded to be in reasonable agreement with theory for an internal bremsstrahlung process. (H.D.R.)

**11524** A NOTE ON THE SUPERSELECTION RULES FOR SPIN-½ BOSONS. R. Spitzer (Argonne National Lab., Ill.). Phys. Letters, 2: 102(Aug. 15, 1962). (In English)

The superselection rules necessary for a physical interpretation of a theory of spin-½ bosons in a Hilbert space with an indefinite metric have been discussed in a Hilbert space with an indefinite metric have been discussed in a previous paper. The one-particle subspace ($H^{(1)}$) of Hilbert space for a system with one type of spin-½ bosons and a single generalized charge was shown to be a direct sum of four orthogonal subspaces ($H_{11} + H_{12} + H_{21} + H_{22}$) that are

separated by superselection rules and each of which is itself coherent. A note is presented to clarify the treatment of the mutual incoherence of the subspaces $H_{12}$ and $H_{22}$ by exhibiting the operator that commutes with all observables and whose eigenvalues distinguish these two subspaces. (H.D.R.)

**11525** MEASUREMENT OF THE POLARIZATION IN 50 Mev PROTON-PROTON SCATTERING AT 45° c.m. C. J. Batty (Rutherford High Energy Lab., N.I.R.N.S., Harwell, Berks, Eng.) G. H. Stafford, and R. Gilmore. Phys. Letters, 2: 109-10(Aug. 15, 1962). (In English)

Measurements of 50 Mev p-p scattering from a thin platinum target were made at scattering angles of 45 and 90° c-m. The polarization for elastic scattering was measured at 45° c-m as 0.0316 ± 0.0017 and at 90° c-m as zero to within the accuracy of the measurement. (H.D.R.)

**11526** EVIDENCE FOR AN EXCITED STATE OF THE ALPHA PARTICLE FROM d + t NEUTRON SPECTRA. C. H. Poppe (Univ. of Wisconsin, Madison). Phys. Letters, 2: 171-2(Sept. 15, 1962). (In English)

Neutron spectra from d + t interactions were observed at deuteron energies from about 5 to 12 Mev at laboratory angles from 0 to 70°, and a typical angular distribution of the spectrum is given for a deuteron energy near 8 Mev. To investigate the way in which the observed high-energy peak arises, Q-values for $T(d,n)He^{4*}$ reactions were calculated. The average value corresponds to an excitation energy in the alpha particle of 20.1 Mev, and the width of the peak falls between 300 and 400 kev. (H.D.R.)

**11527** ON THE VELOCITY-DEPENDENT NUCLEON–NUCLEON POTENTIAL OF GREEN. M. A. Preston, P. J. Armstrong, and R. K. Bhaduri (McMaster Univ., Hamilton, Can.). Phys. Letters, 2: 183-5(Sept. 15, 1962). (In English)

The nucleon-nucleon velocity-dependent potential $V(r) + (p^2/m_0)\,\omega(r) + \omega(r)(p^2/m_0)$ is investigated, where V(r) is the central, tensor, and spin-orbit potentials, p is the relative momentum, r the relative coordinate, and $m_0$ the nucleon mass. The nuclear-bar phase-parameters were calculated up to J = 5, solving the coupled Schrödinger equations numerically, at laboratory energies of 90, 156, and 310 Mev. All the singlet phase-shifts up to l = 5 were calculated at the same energies. As an application and a test of this potential to a nuclear problem where all the phase-parameters are needed, the integrated optical potential (central and spin-orbit parts) were calculated using a formalism of previous investigators. (H.D.R.)

**11528** ON THE $\pi$-$\pi$ INTERACTION PUZZLE IN $\tau$-DECAY. L. T. Smith, D. J. Prowse, and D. H. Stork (Univ. of California, Los Angeles). Phys. Letters, 2: 204-7 (Sept. 15, 1962). (In English)

A total of 948 $\tau^-$ decays was produced in a bubble chamber by 600, 760, and 860 Mev/c $K^-$ beams. Least-squares linear and quadratic fits are tabulated for the dependencies of the matrix element on a number of decay variables. Data from other investigations on both $\tau^-$ and $\tau^+$ decay are combined with the new data in order to summarize the evidence for the $\pi$-$\pi$ interactions in the decay. The differences in the quadratic terms are found to be too large to make a choice between various theories. To demonstrate the reality of a quadratic term in $\tau$ decay will require at least an order of magnitude increase in the number of events. (H.D.R.)

**11529** DIFFERENCES BETWEEN CROSS SECTIONS IN THE MULTIPERIPHERAL MODEL. H. Pilkuhn (Univ. of Stockholm). Phys Letters, 2: 207-8(Sept. 15, 1962). (In English)

It has been suggested in previous investigations that certain combinations of high-energy cross sections obey energy power laws of a type obtained from the multiperipheral model. This model is shown here to predict the right signs for the known differences between high-energy cross sections, provided that in the low-energy region $\sigma_0(\pi^-\pi^+) > \sigma_0(\pi^+\pi^+)$, $\sigma_0(\pi^-K^+) > \sigma_0(\pi^+K^+)$, and $\sigma_0(\bar{K}K) > \sigma_0(KK)$. (H.D.R.)

**11530** REGGE TRAJECTORY AND RESONANT PARTIAL WAVE AMPLITUDE. Padmanabha Dasgupta (Saha Inst. of Nuclear Physics, Calcutta). Phys. Letters, 2: 273(Oct. 15, 1962). (In English)

For the Coulomb potential, it has been proved that the position of a Regge pole is analytic on the complex energy plane except for a cut along the real axis from E = 0 to ∞. It has also been pointed out that this is likely to be true for any general potential. Some possible consequences of this conjecture are briefly discussed. (W.D.M.)

**11531** ELECTROMAGNETIC TRANSITIONS FOR THE PHOTODISINTEGRATION OF THE DEUTERON. Masahiko Matsumoto (Univ. of Alberta, Edmonton). Phys. Rev., 129: 1334-41(Feb. 1, 1963).

Over-all electromagnetic transitions for the photodisintegration of the deuteron are examined in the energy range 162 to 833 Mev. The virtual meson exchange interaction is not considered. The electromagnetic interactions are treated without any series expansion. Therefore, all multipole transitions and their retardations are completely taken into account in the calculations. The pion-theoretical deuteron wave function and plane waves are used for the initial and final states, neglecting the effects of the hard core in the nucleon-nucleon potential. It is then shown that the angular dependence of those terms which are simply isotropic in the electric dipole approximation is given approximately by the isotropic part in the electric dipole transition, plus a cosine curve due to the overlap effects of the higher multipole transitions, as well as overlap effects due to all retardations. The terms which reduce to the anisotropic terms in the electric dipole approximation give angular distributions which are shifted forward from $\sin^2\theta$ but which tend to flatten out with increasing energy. The separate retardation effects due to the dipole and other multipole terms cannot be distinguished in the present calculation. For some reason the total cross sections seem to fit the experimental data fairly well at energies higher than 400 Mev when only the electric transitions are taken into account. However, the total cross sections including magnetic transitions are about four times the experimental data at 800 Mev. The contribution of the magnetic transitions to the cross sections does not decrease as much with energy as does the contribution due to the electric transitions and remains relatively large at high energy. The effect of disregarding the hard core is large for the spin magnetic transitions. (auth)

**11532** HYPERONS WITH AND WITHOUT DOUBLET SYMMETRY. [PART] II. Gregor Wentzel (Univ. of Chicago). Phys. Rev., 129: 1367-72(Feb. 1, 1963).

Earlier work on hyperon isobars (resonances) based on a static strong-coupling approximation is continued. New results are derived, in particular for values near ±1 and near 0 of the ratio of the two coupling constants ($\Sigma\Sigma\pi$ to $\Lambda\Sigma\pi$). The orbital angular momentum l of a stationary (or resonant) state is unambiguously defined through the eigenfunctions of the bound-pion Hamiltonian. For instance a resonance with l = 2 and isospin 0 is predicted if the direct $\Sigma\Sigma\pi$ coupling is very weak or absent. (auth)

**11533** ELASTIC SCATTERING OF LAMBDA HYPERONS FROM PROTONS. Thomas H. Groves (Univ. of Wis-

consin, Madison). Phys. Rev., 129: 1372-7(Feb. 1, 1963). (TID-16517)

The Λ-proton elastic scattering cross section has been measured to be 20 ± 5 mb. This value represents an average over the momentum interval 150–1500 Mev/c. It is based on 26 events observed in a propane bubble chamber. The Λ hyperons were produced by the interactions of 1.15-Bev/c $K^-$ mesons in the propane. (auth)

**11534** $K_{l4}$ DECAYS AND THE STRUCTURE OF THE $\Delta S = 1$ CURRENTS. A. Sirlin (New York Univ., New York and Universidad, Buenos Aires). Phys. Rev., 129: 1377-8 (Feb. 1, 1963).

It is shown that the search for various modes of $K_{l4}$ decays may give valuable information regarding the structure of the strangeness-nonconserving currents. At the same time such a search provides a severe test for a class of theories of weak interactions, in which all charged currents are coupled to the leptonic current and satisfy the abstract properties of Gürsey's model. (auth)

**11535** MODIFICATION OF THE ONE-PION-EXCHANGE MODEL FOR $\pi^- + p \rightarrow \pi^- + \pi^+ + n$. G. L. Shaw and D. Y. Wong (Univ. of California, San Diego). Phys. Rev., 129: 1379-81(Feb. 1, 1963)

The one-pion-exchange model for the production process $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ is modified to include a tensor component for the exchanged pion off its mass shell. This modification is suggested by the hypothesis of the Regge pole description for the pion. Experimental evidence for the deviation from the ordinary one-pion-exchange model can be understood in the present theory provided the final-state $\pi^-\pi^+$ pair contains an appropriate mixture of $J = 0$ and $J = 1$ ($\rho$ meson) amplitudes. (auth)

**11536** RADIATIVE $\tau^+$ DECAY. E. L. Koller, S. Taylor, T. Huetter, and P. Stamer (Stevens Inst. of Tech., Hoboken, N. J.). Phys. Rev., 129: 1381-2(Feb. 1, 1963).

A clear example of a radiative $\tau^+$ decay, $K^+ \rightarrow \pi^+ + \pi^+ + \pi^- + \gamma$, has been found in nuclear emulsion. The photon energy is 34 ± 1 Mev. (auth)

**11537** ELEMENTARY PARTICLE CLASSIFICATION BASED UPON A MASSLESS DIRAC FIELD. John C. Fisher (General Electric Research Lab., Schenectady, N. Y.). Phys. Rev., 129: 1414-19(Feb. 1, 1963).

Elementary particles are viewed as linearized excitations of a nonlinear massless Dirac field, whose ground state is assumed to contain a finite density of field quanta. Nucleons and antinucleons are viewed as single-particle and single-hole excitations, and other elementary particles as space-symmetric correlations of 2, 3, 4 particles and holes. Hyperons are viewed as composite. The strangeness quantum number is identified with half the excess of particles over holes in the excitation. The classification has room for 29 particles: the known elementary particles plus doubly charged K and $\mu$ mesons and antiparticles, a strange charged spin 1 boson and antiparticle, and a boson quintet of strangeness and charge 0, ±1, ±2. (auth)

**11538** COULOMB INTERACTIONS IN A STRONG MAGNETIC FIELD. I. ADIABATIC CASE. Robert Goldman and Ludwig Oster (Yale Univ., New Haven). Phys. Rev., 129: 1469-78(Feb. 1, 1963).

The line contour of cyclotron radiation from free electrons is derived quantum mechanically, including the effects of Coulomb interactions on the time-varying part of the wave functions ("adiabaticity") as a perturbation in the Hamiltonian. The computation is similar to Lindholm's theory of atomic lines. The results, line shifts and half-widths, i.e., collision cross sections, are given for a variety of physical conditions. The limitations of the treatment are discussed.

**11539** POSITRON ANNIHILATION IN METALS. S. Kahana (Univ. of Copenhagen). Phys. Rev., 129: 1622-8 (Feb. 15, 1963).

An adequate description of positron annihilation rates in metals is obtained by extension of the high-density limit, for annihilation in an electron gas, to realistic densities. A short-range electron-positron force is obtained in the high-density limit and is used to treat accurately the two-body correlations between the positron and metallic valence electrons. This description proves to be satisfactory for metals with low valence electron densities as well. The variation of annihilation rates with valence electron density, and also the absolute rates, agree quite well with those obtained experimentally by Bell and Jørgensen. (auth)

**11540** SLIGHTLY-INELASTIC PROTON-DEUTERON SCATTERING. D. G. Stairs, Richard Wilson, and P. F. Cooper, Jr. (Harvard Univ., Cambridge, Mass.). Phys. Rev., 129: 1672-9(Feb. 15, 1963).

Measurements of the inelastic p-d cross section, in the region of very small momentum transfer, have been made at laboratory scattering angles of 5°, 10°, 15°, and 20°. The elastic p-d cross section has also been measured at these angles and compared with Postma's data. These measurements have been performed with a high-resolution magnetic spectrometer designed especially for this experiment. The p-d cross sections have been obtained by normalizing the p-d spectra to p-p spectra obtained by filling the same target with liquid hydrogen. The shape of the p-p spectrum, at a particular angle, was used to effect the separation of the inelastic p-d from the elastic p-d spectrum. The overall energy resolution at small angles was about 0.75%. A comparison of the elastic p-d data with the impulse-approximation calculation of Kerman, McManus, and Thaler yielded a value of $\Sigma_t$, the triplet amplitude sum, at the four angles measured. The singlet amplitude sum, $\Sigma_s$, was obtained by fitting Cromer's theory to the inelastic p-d cross section. The experimental values of the parameters $\Sigma_s$ and $\Sigma_t$ are compared with the predictions of the most recent phase-shift analyses. $\Sigma_s$ appears to be particularly sensitive to the values of the $T = 0$ amplitudes and thus experimental values of $\Sigma_s$ may be useful in future phase-shift analyses. (auth)

**11541** MUON CAPTURE ON CARBON. G. T. Reynolds, D. B. Scarl, R. A. Swanson, J. R. Waters, and R. A. Zdanis (Princeton Univ., N. J.). Phys. Rev., 129: 1790-4 (Feb. 15, 1963).

To check the predictions of a universal Fermi interaction, negative muons were brought to rest in a $1\frac{1}{2}$-in. filament scintillator chamber and the rate for the reaction $\mu^- + C^{12} \rightarrow B^{12} + \nu$ was measured. Ninety-seven $B^{12}$ events were observed, giving a capture rate of $(6.6 \pm 0.9) \times 10^3$/sec. This number is in agreement with the predictions of a universal Fermi interaction, a pion-induced pseudoscalar term with $g_P = +8g_A$, and a conserved vector current. (auth)

**11542** $K^*$ SPIN AND THE ISOVECTOR KAON CHARGE. Alberto Pignotti (Univ. of California, Berkeley). Phys. Rev., 129: 1807-8(Feb. 15, 1963). (UCRL-10467)

The isovector kaon charge is calculated using an unsubtracted dispersion relation for the kaon form factor. The $\pi\pi$-$K\bar{K}$ amplitude appearing in the form factor discontinuity is evaluated by using unitarity and crossing symmetry, and thus is related to the experimental values of the $\rho$ and $K^*$ energies and widths. It is shown that the correct order of

magnitude for the kaon charge is obtained if the K* spin is one and not if it is zero. (auth)

**11543** EXPERIMENTAL INVESTIGATION OF PION ELECTROPRODUCTION. L. N. Hand (Stanford Univ., Calif.). Phys. Rev., 129: 1834-46(Feb. 15, 1963).

Measurements of the total cross section for the processes $e + p \rightarrow e' + n + \pi^+$ and $e + p \rightarrow e' + p + \pi^0$ are reported for a wide range of center-of-mass energies and momentum transfers extending above the first pion-nucleon resonance and to momentum transfers of 20 $F^{-2}$. Only the final electron is observed in this experiment. Results are analyzed in terms of nucleon form factors using experimental pion-nucleon phase shifts and the theory of Fubini, Nambu, and Wataghin. In general, the data seem consistent with current picture of nucleon structure, except for a preference for a negative rather than positive neutron-electric form factor, $G_{En}$. It is demonstrated from the electron angular distribution for constant momentum transfer and constant center-of-mass energy that pion electroproduction does in fact occur primarily through transverse currents. The general form of the separation into transverse and scalar photons for inelastic or elastic electron scattering is discussed. In addition, an approximate formula for the background process of wide-angle bremsstrahlung is quoted which appears to be accurate to 1–2% over a very wide range of electron and photon energies when compared to a numerical computation by a digital computer. (auth)

**11544** PION-PION INTERACTIONS IN THE STATES T = 0 AND T = 1. T. D. Spearman (University Coll., London). Phys. Rev., 129: 1847-57(Feb. 15, 1963).

New dispersion relations are derived for the s-wave pion-nucleon scattering amplitudes. These relations are specifically chosen to facilitate the task of separating the two-pion exchange term from the other effects contributing to low-energy pion-nucleon scattering. In these equations the contribution from the unknown short-range terms is markedly suppressed, a greater emphasis is placed on the experimentally better established very low energy pion-nucleon data, in particular on the scattering lengths, and in the contribution of the two-pion exchange term the lower energies are more heavily stressed. The terms due to the two-pion exchange, which we isolate, are very clearly recognized by their characteristic energy dependences. The two-pion exchange terms are analyzed in terms of the interaction between the two pions. The values obtained for these terms are made to yield information about the phase shifts for pion-pion scattering in the T = 1 and T = 0 states. In the T = 1 state the data are well fitted with a narrow p-wave resonance in the pion-pion system at 750 Mev. Taking the results of electron-nucleon scattering experiments in conjunction with the present data, the half-width of this resonance is found to lie between 40 and 60 Mev, in agreement with the experimental data for the observed $\rho$ meson. In the T = 0 state the data are fitted with a two-parameter form for the s-wave pion-pion phase shift. Both of these parameters are not simultaneously determined by the present data. As an added restriction on the phase shift it is required to lead to agreement with the experimental results for the process $p + d \rightarrow He^3 + 2\pi$. This singles out a T = 0 s-wave phase shift with a scattering length of $a_0 \approx 1.6$ (units $\hbar = \mu = c = 1$). (auth)

**11545** POSSIBLE DETERMINATION OF THE SPIN OF THE $\Xi^-$ FROM THE ANGULAR ASYMMETRY OF ITS DECAY. Murray Peshkin (Argonne National Lab., Ill.). Phys. Rev., 129: 1864-6(Feb. 15, 1963). (TID-17468; UAC-6910)

The $\Xi^-$ hyperon is produced in a parity-conserving interaction involving only a proton and two spinless K mesons. Therefore, the $\Xi^-$ beam in any direction consists of an equal, incoherent mixture of two pure spin states which go into each other under 180° rotation in the production plane. This condition implies a new restriction upon the angular distribution of the $\Xi^-$ decay products. In particular, the distribution $I(\theta,\phi) = 1 + A\cos\theta$ is impossible for $A \neq 0$ unless the $\Xi^-$ spin is $\frac{1}{2}$. (auth)

**11546** REGGE POLES IN $\pi$N SCATTERING AND IN $\pi + \pi \rightarrow N + \bar{N}$. Virendra Singh (Univ. of California, Berkeley). Phys. Rev., 129: 1889-96(Feb. 15, 1963). (UCRL-10416)

The Regge-Froissart continuations of various partial-wave amplitudes for $\pi$N scattering are introduced into the complex J plane. The notion of J parity is clarified by considering parity nonconservation. The analyticity and symmetry properties of the Regge-Froissart continuation in the energy plane are also studied and the results of analysis applied to backward pion-proton scattering. A similar discussion is given of the $\pi + \pi \rightarrow N + \bar{N}$ channel and the forward elastic pion-proton scattering. (auth)

**11547** ANNIHILATION OF ANTIBARYONS. Y. Eisenberg (Massachusetts Inst. of Tech., Cambridge). Phys. Rev. Letters, 10: 60-2(Jan. 15, 1963).

The $\pi$ mesons surrounding any nucleon or antinucleon can have any charge; the strange meson cloud of a nucleon (antinucleon), however, may contain only $K^+$ and $K^0$ mesons ($K^-$ and $\bar{K}^0$ mesons), at least for dissociation to single mesons. Some consequences of this type of asymmetry in the strange-meson clouds surrounding baryons and antibaryons are discussed. Effects on the distributions of strange and normal particles from annihilation of particles on antiparticles are described. (T.F.H.)

**11548** INFRARED DIVERGENCE AND POSITRONIUM SPECTRUM. H. Suura and D. R. Yennie (Univ. of Minnesota, Minneapolis). Phys. Rev. Letters, 10: 69-70 (Jan. 15, 1963).

The relation of the positronium spectrum to the infrared factor involved in the scattering of electrons is explained. It is shown that the infrared phase proportional to $\ln \lambda$ ($\lambda$ = photon mass) gives the asymptotic radial dependence of the electron-positron scattering, and that by matching this phase with an approximate asymptotic radial function of a bound state, a relation that determines the positronium spectrum can be found. (T.F.H.)

**11549** ELECTRON SCATTERING BY AN INTENSE POLARIZED PHOTON FIELD. Richard H. Milburn (Tufts Univ., Medford, Mass.). Phys. Rev. Letters, 10: 75-7 (Feb. 1, 1963).

It was shown that one may expect to obtain on the order of several thousand collimated high-energy scattered photons, and that these quanta retain the polarization of the original beam of optical photons by using existing laser systems and electron accelerators. The total number of scatterings were independent of the duration of the light pulse and depended upon the total light energy per unit area of the beam. (C.E.S.)

**11550** THOMSON SCATTERING OF OPTICAL RADIATION FROM AN ELECTRON BEAM. G. Fiocco and E. Thompson (Massachusetts Inst. of Tech., Cambridge). Phys. Rev. Letters, 10: 89-91(Feb. 1, 1963).

Light from a ruby laser was focused to intersect an electron beam at right angles, and the scattered radiation was observed at an angle $\Theta = 65°$ with respect to this beam. Intensity of the radiation was $10^{-18}$ of the laser output; de-

tected by a photomultiplier after it passed through an iris and a system of filters. (C.E.S.)

**11551** POLARIZATION OF NEUTRONS FROM THE PHOTODISINTEGRATION OF DEUTERIUM. W. Bertozzi (Massachusetts Inst. of Tech., Cambridge), P. T. Demos, S. Kowalski, C. P. Sargent, W. Turchinetz, R. Fullwood, and J. Russell. Phys. Rev. Letters, 10: 106-8(Feb. 1, 1963). (TID-17531)

The measurement was performed using a linac operated at ~30 Mev with ~6 kw of beam power. The bremsstrahlung target, 0.014 in. of tantalum backed with 8 in. of water, was enclosed by about 1 ft of iron and 2 ft of water. A hole in the shielding allowed the collimated bremsstrahlung beam to impinge on a (γ,n) target 4 ft from the tantalum. The neutrons were viewed through a collimation system at 90° to the photon beam by a neutron spectrometer polarimeter. Percent polarization of photoneutrons from deuterium was computed. (C.E.S.)

**11552** EXPERIMENTAL DETERMINATION OF THE BRANCHING RATIO $\Gamma(\eta \to \pi^+\pi^-\gamma)/\Gamma(\eta \to \pi^+\pi^-\pi^0)$. Earle C. Fowler (Duke Univ., Durham, N. C.), Frank S. Crawford, Jr., L. J. Lloyd, Ronald A. Grossman, and LeRoy Price. Phys. Rev. Letters, 10: 110-14(Feb. 1, 1963).

The experimental procedures and cutoffs that were applied to a sample were given in detail and the results compared with theoretical predictions. (C.E.S.)

**11553** COMPARISON OF $\eta$, $\tau$, AND $\tau'$ DECAYS. D. Berley, D. Colley, and J. Schultz (Columbia Univ., New York). Phys. Rev. Letters, 10: 114-16(Feb. 1, 1963).

Pion spectra from $\eta$, $\tau$, and $\tau'$ decays were compared assuming that the three final pions have isotropic spin 1. The comparison between $\eta$ and $\tau'$ assumed that the decay processes proceeded through a one-pion intermediate. The number of observed $\tau'$ decays was small, while $\tau$ data were extensive. The relation between $\tau$ and $\tau'$ provided a means of comparing the $\tau'$ and $\eta$ decays. (C.E.S.)

**11554** THRESHOLD ANOMALIES IN INELASTIC COLLISIONS. Andrzej Deloff (Inst. of Nuclear Research, Polish Academy of Sciences, Warsaw). Postepy Fiz., 13: 549-62(1962). (In Polish)

The elastic cross section in a two-particle collision can take on an infinite slope just at the threshold of a different (inelastic) reaction. The shape of the cross section versus energy curve can take the form of a positive or negative spike at the threshold energy, or the slope of the curve can be continuous in sign but very large at threshold energy. Although these effects were at first believed to be too small to be of importance, work of the past few years showed that this effect can furnish information relating to the reaction products as well as to the dynamics of the collision process. Information that can be obtained from studying cross sections near threshold energies is the parity of elementary particles. The elementary theory, including spin effects, and a review of the most important theoretical and experimental results in this area are presented. The possibility of obtaining indirect information about the interaction between elementary particles that could not be obtained by direct scattering experiments is discussed. (TTT)

**11555** EFFICIENCY OF γ QUANTA RECORDING BY MONOCHROMATIC BREMSSTRAHLUNG BEAM. V. P. Agafonov, B. B. Govorkov, S. P. Denisov, and E. V. Menarik (Inst. of Physics, Academy of Sciences, USSR). Pribory i Tekhn. Eksperim., No. 5, 47-50(Sept.-Oct. 1962). (In Russian)

Production of monoenergetic γ quanta by means of a bremsstrahlung beam is described, and application of the method in determining high-energy γ detector efficiency is shown. The method is based on recording the γ bremsstrahlung in coincidence with the emitting electron. Magnetic spectrometers are used for measuring the electron energy before and after emission. The difference determines the energy of the recorded γ quantum. Electrons were produced by conversion in a lead target placed in a 265-Mev synchrotron bremsstrahlung beam. The method offers high energy resolution (~1%). (tr-auth)

**11556** STRANGE PARTICLES. K. I. Shchelkin. Priroda, No. 12, 10-18(Dec. 1962). (In Russian)

A popular survey is given of the properties and classifications of strange particles. A table showing the mass, isotopic spin lifetime, name, and classification of particles is included. (R.V.J.)

**11557** NOTE ON UNITARY SYMMETRY IN STRONG INTERACTION. II. EXCITED STATES OF BARYONS. Susumu Okubo (Univ. of Tokyo and Univ. of Rochester, N. Y.). Progr. Theoret. Phys. (Kyoto), 28: 24-32(July 1962). (In English)

A classification of the baryon isobars is investigated on the basis of a unitary symmetry model. (auth)

**11558** A MODEL FOR PHYSICAL NUCLEON. Isao Umemura (Nagoya Univ., Japan). Progr. Theoret. Phys. (Kyoto), 28: 113-26(July 1962). (In English)

The anomalous magnetic moment of the nucleon is investigated by taking the possible excitations of the nucleon core or the pion cloud into account. For the sake of definiteness and simplicity two assumptions are made, namely that the physical nucleon is composed of the static core accompanied by one or no cloud particle, and that the virtual excitations can be treated as the occurrence of particles having definite spin J, isospin I, parity P, and mass with some probability. As the virtual excitations, the occurences of cores of $I = J = 3/2$; $I = 1/2$, $J = 3/2$; $I = 1/2$, $J = 5/2$; etc., and of cloud particles with $I = J = 1$; $I = 1$, $J = 0$; etc., are considered. It is shown that the most favorable model for the physical nucleon is the one in which the nucleon is assumed to consist of the cores of $I = J = 1/2$, $P = (+)$, and $I = J = 3/2$, $P = (+)$ with nearly equal weight, the former being accompanied by one or no pion and the latter being accompanied by one pion. Using this model, p-wave $\pi^+$-P scattering is also discussed to indicate the consistency of the approach. (auth)

**11559** ELECTROMAGNETIC STRUCTURE OF THE NUCLEON. EFFECTS OF PION CORRELATIONS ON THE ISO-SCALAR FORM FACTORS. Ken Kawarabayashi and Akira Sato (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 28: 173-204(July 1962). (In English)

The three-pion state contribution to the isoscalar electromagnetic structure of the nucleon is investigated in detail, with the effects of two-pion and three-pion resonances. The effects of these resonances are formulated so as to be represented by respective enhancement factors to the lowest-order perturbation calculations on the basis of unitarity and analyticity requirements. Numerical calculations show that the results of the perturbation calculations with an extended effective $\gamma$-3$\pi$ interaction are greatly modified by including the pion correlations. In particular, the calculated mean-square radius of the isoscalar charge distribution turns out to be in agreement with experiment when the effects of both the two-pion and three-pion resonances are taken into account. The charge form factor thus calculated reproduces the experimental curve in the low momentum transfer region $q^2 < 15\mu^2$. The anomalous magnetic moment, on the other hand, is positive and large in magnitude even after the inclusion of these resonances. (auth)

**11560** BRANCHING RATIOS IN ISOBAR MODEL FOR $K^-$-p COLLISIONS. Vinod Prakash Gautam, Yogendra Mohan Gupta, and Bipin Kumar Agarwal (Allahabad Univ., India). Progr. Theoret. Phys. (Kyoto), 28: 207-8(July 1962). (In English)

The branching ratios for reactions $K^- + p \rightarrow Y + 2\pi$ are calculated in the isobar model, taking into account $\Lambda\pi$ and $\Sigma\pi$ resonances. $Y = \Lambda$ or $\Sigma$. The relative probabilities for $\Sigma^0$(or $\Lambda^0$) + $2\pi^0$ production are found to be zero. The cross sections are also discussed. (T.F.H.)

**11561** HYPOTHESIS OF ISOTOPIC SPIN INDEPENDENCE, PERIPHERAL AND CENTRAL INTERACTIONS IN THE HIGH ENERGY LIMIT. Masaaki Kawaguchi (Osaka Univ.). Progr. Theoret. Phys. (Kyoto), 28: 829-45(Nov. 1962). (In English)

Some consequences of the following three assumptions in the high energy limit are given: Assumption I. If the total cross section of strongly interacting particles is expressed by the sum of cross sections corresponding to the total isotopic spins $I = I_{max}, I_{max} - 1, \ldots, I_{min}$, these cross sections tend to a constant independent of I. Assumption II. If the S-matrix of a reaction is given by the sum of the S-matrices corresponding to $I_{max}, I_{max} - 1, \ldots, I_{min}$, these S-matrices are independent of I. Assumption III. In addition to Assumption II, the S-matrices are independent of strangeness, sign of nucleon numbers of participating particles, hypercharge and so forth. The process $\pi^+ + p \rightarrow N + 2n\pi$ is discussed under II. This process is also investigated in simple models of one pion exchange peripheral collision and in a model of central collision, comparing with the result of II. A consequence of II is $\sigma(\pi^- + p \rightarrow N + 2n\pi) = \sigma(\pi^+ + p \rightarrow N + 2n\pi)$, where $\sigma(\pi^\pm + p \rightarrow N + 2n\pi)$ means the sum of the cross sections over possible charge combinations in the final state. For the peripheral and central collisions we get $\sigma(\pi^- + p \rightarrow N + 2n\pi) > \sigma(\pi^+ + p \rightarrow N + 2n\pi)$. One of the differences of the peripheral, central, and isotopic spin independent collisions is seen in the charge ratios of the cross sections for small n. Consequently, it is suggested that a possible model of high energy collision, which satisfies the inequality of the total cross sections $\sigma(\pi^- + p) > \sigma(\pi^+ + p)$, is the peripheral interaction due to pion-pion interactions. The difference $\sigma(\pi^- + p) - \sigma(\pi^+ + p)$ in this theory is expected to vanish in the high energy limit, so that this model is approximately isotopic spin independent. The central collisions should, however, be considered equally important as the peripheral collisions so long as the present discussion is concerned. (auth)

**11562** A MODEL OF WEAK INTERACTION. Hiroshi Yamamoto (Fukui Univ., Japan). Progr. Theoret. Phys. (Kyoto), 28: 881-4(Nov. 1962). (In English)

Weak interactions are interpreted from the standpoint of a composite model like the Nagoya model with two neutrinos ($\nu_e$ and $\nu_\mu$). A new boson called $\epsilon'$-charge is introduced. It has nearly the same properties as the $\epsilon$-charge (negative charged vector boson), and has no strong interaction with leptons. Assuming a suitable interaction Lagrangian between $\epsilon$, $\epsilon'$, $\nu_e$, and $\nu_\mu$, and that $\epsilon'$ plays a role of an intermediate boson which generates weak interactions, all the leptonic and non-leptonic decay processes can be explained naturally except the $\Delta S = -\Delta Q$ process. (auth)

**11563** PION PRODUCTION FROM $\nu$ + N OR $\bar{\nu}$ + N COLLISIONS IN THE PERIPHERAL INTERACTION MODEL. [PART] I. Mineo Fukawa (Tokyo Univ. of Education). Progr. Theoret. Phys. (Kyoto), 28: 885-903(Nov. 1962). (In English)

The cross sections for $\nu$ + N and $\bar{\nu}$ + N reactions with single pion and double pion productions are evaluated assuming the one-pion-exchange model including 3-3 resonance. This model is similar to the peripheral interaction model of $\pi$-$2\pi$, $\pi$-$3\pi$, ... reactions, and enables one to investigate the consistency with strong interaction models. The cross sections are calculated numerically at incident energy 1 Bev, 3 Bev, and 5 Bev, respectively. (auth)

**11564** DOUBLE PION PHOTOPRODUCTION AND THE $\gamma$-$3\pi$ VERTEX. Minoru Monda (Tokyo Metropolitan Univ.). Progr. Theoret. Phys. (Kyoto), 28: 904-14(Nov. 1962). (In English)

The $\gamma$-$3\pi$ vertex interaction is discussed in order to understand the steep rising of the total cross section for the $\gamma + p \rightarrow p + \pi^+ + \pi^-$ reaction up to $E_\gamma \sim 550$ Mev. The static theory, which includes the final (3,3) resonance state interaction and the source function for the nucleon, is used. The E1 $\rightarrow sp_{\frac{1}{2}}$ transition is assumed to be large. The meson and nucleon current interactions have small contributions. The so-called interaction current is not enough to explain this steepness. By adding the $\gamma$-$3\pi$ interaction term, the sharp rising can be reproduced if the order of magnitude of the $\gamma$-$3\pi$ coupling constant ($\lambda$) is $|\lambda| \sim 0.088$, which is not inconsistent with the value estimated from other phenomena. Experiments to test the assumptions are discussed. (auth)

**11565** $(\gamma,3\pi)$ VERTEX AND DOUBLE $\pi^0$ PHOTOPRODUCTION. Kiyomi Itabashi (Tokyo Univ.) and Takeshi Ebata. Progr. Theoret. Phys. (Kyoto), 28: 915-33(Nov. 1962). (In English)

Effects of the $(\gamma,3\pi)$ vertex in the reaction $\gamma + p \rightarrow p + 2\pi^0$ is studied. It is shown that the $(\gamma,3\pi)$-part of the amplitude for this reaction is given by the "meson current part" of the amplitude for the single $\pi^0$ production by a virtual photon, multiplied by a certain numerical factor including the effective coupling constant of the $(\gamma,3\pi)$ vertex. Thus Thus referring to the theory of Fubini, Nambu, and Watagin for the single pion electroproduction, the $(\gamma,3\pi)$-part of the double $\pi^0$ photoproduction amplitude can be obtained almost exactly. It is also shown that, under appropriate experimental conditions, the major contribution to the reaction $\gamma + p \rightarrow p + 2\pi^0$ comes from the absorption of the incident photons via the $(\gamma,3\pi)$ vertex, unless its effective coupling constant $\lambda$ be much smaller than the value expected from the simple perturbation calculation. Thus, the experimental study of this reaction would possibly provide an alternative and rather unambiguous method for the determination of $\lambda$. An example for such a measurement is proposed, and the cross section under the proposed conditions is calculated. (auth)

**11566** PHENOMENOLOGICAL ANALYSIS OF THE HIGH-ENERGY COLLISION OF ELEMENTARY PARTICLES. Masakuni Ida (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto). 28: 945-6(Nov. 1962). (In English)

In the preceding letter a semi-classical picture was derived without any particular approximation for the elastic scattering of high-energy particles. Some interesting conclusions follow if two simplifying assumptions are added: first that the real part of the scattering amplitude is negligible compared to the imaginary part and second that the differential elastic cross section is given by $a_{el}(s,t)/a_{el}(s,o) \approx e^{\alpha(s)t}$. (W.D.M.)

**11567** $\Xi^-$ CAPTURE AT REST BY HYDROGEN. Yoshio Yamaguchi (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto). 28: 948(Nov. 1962). (In English)

Recent data on the cascade hyperons seem to indicate the existence of $\Xi^-$ capture at rest by hydrogen via the charge exchange mode: $\Xi^- + p \rightarrow \Xi^0 + n$ + (several Mev). This will compete with the familiar capture mode $\Xi^- + p \rightarrow \Lambda^0 + \Lambda^0 +$

26 Mev. These two processes are discussed briefly. (W.D.M.)

**11568** ASPECTS OF NUCLEON-NUCLEON SCATTERING THEORY. G. Breit (Yale Univ., New Haven). Rev. Mod. Phys., 34: 766-812(Oct. 1962). (TID-16175)

Selected aspects of nucleon-nucleon scattering are critically reviewed. Phase shifts are treated relativistically in a manner similar to the usual non-relativistic one. Relativistic kinematics, nonrelativistic treatments, low-energy p-p scattering, corrections to Coulomb scattering, the form of the N-N scattering matrix, and the effects of nucleon magnetic moments are considered. General views regarding N-N interactions, the one-pion exchange interaction, tests of charge independence, and evidence concerning two-pion exchange are surveyed. Attempts to explain the still somewhat hypothetical spin-orbit potential and repulsive core by means of heavy mesons strongly interacting with nucleons are discussed. (W.D.M.)

**11569** ON THE REPRESENTATIONS OF THE ROTATION GROUP. V. Bargmann (Princeton Univ., N. J.). Rev. Mod. Phys., 34: 829-45(Oct. 1962).

In a recent article (V. Bargmann, Comm. Pure Appl. Math., 14: 187(1961)) a family of Hilbert spaces were studied whose elements are entire analytic functions of n complex variables. The methods developed therein appear appropriate for a fairly effortless treatment of the representation theory of the rotation group. Further applications of these methods are considered. (W.D.M.)

**11570** ELASTIC SCATTERING CROSS SECTIONS FOR COLLISIONS BETWEEN SPIN-3/2 AND SPIN-0 PARTICLES. I. Brăndus (Inst. of Nuclear Physics, Bucharest). Rev. Phys., Acad. Rep. Populaire Roumaine, 7: 437-46(1962). (In French)

Elastic cross sections are calculated for the scattering of initially unpolarized spin-$\frac{3}{2}$ particles by spin-0 particles. The cross sections are expressed in terms of phase shifts of scattered waves. The scattering expression can be used to calculate the phase shifts in terms of the experimental scattering parameters. The spin dependence of the scattering matrix is expressed directly in matrix form, so that the determination of the phase shifts is completely equivalent to the determination of the scattering matrix. Thus by calculating the mean values in the final state of the irreducible spin tensors, values may be obtained that completely characterize the state of the scattered particles. (T.F.H.)

**11571** THE RIEMANN-CAUCHY RELATIONSHIPS IN THE THEORY OF PION-NUCLEON INTERACTION. M. Zaganescu. Rev. Phys., Acad. Rep. Populaire Roumaine, 7: 125-9(1962). (In French)

The dispersion relation appearing in the theory of pion-nucleon interaction are derived from the Cauchy formula. Relations equivalent to the dispersion relations are established by using the Riemann-Cauchy formulas. (J.S.R.)

**11572** ANALYTICAL PROPERTIES OF PARTIAL WAVE SCATTERING AMPLITUDES OF CHARGED PARTICLES. II. ARBITRARY l. Yu. L. Mentkovskii. Ukr. Fiz. Zh., 7: 965-6(Sept. 1962). (In Ukrainian)

A study is made of the case of any angular momentum l, the particles being considered as solid spheres of finite radius. A section along the negative ray of the imaginary axis, which is the line of the possible discontinuity of a given function $M_l(k)$, is the line of the real discontinuity of $M_l(k)$ if the core is considered to be solid. Certain additional properties of $M_l(k)$ are discussed. (auth)

**11573** RELATIVISTIC CORRECTIONS FOR THE SMALL-ANGLE THEORY OF MULTIPLE SCATTERING. Hans H. Fleischmann (Technische Hochschule, Munich). Z. Naturforsch., 17a: 930-2(Oct. 1962). (In German)

A relativistic correction of the multiple scattering distribution of charged particles at small angles was derived previously (Z. Naturforsch., 15a: 1090(1960)). The numerical evaluations of the correction function are given in tabular form. The results obtained by Hanson et al. for scattering distributions on gold foils were compared with the theoretical results obtained with the relativistic correctors. The results show for scattering angles under 20° the theoretical and experimental results disagree by only a few percent, but if one assumes an error of absolute calibration of less than 5%, the deviations from the measuring point are several percent higher. Use of the correction factors causes a marked improvement of the Molière theory of multiple scattering. (J.S.R.)

**11574** COMPTON SCATTERING ON PROTONS. Volkhard F. Mueller (Universität, Heidelberg) Z. Physik, 170: 114-30(1962). (In German)

Fixed momentum-transfer dispersion relations were applied to calculate differential cross sections for $\gamma$-proton scattering. No kinematical approximations are performed. The absorptive part of the scattering amplitude is calculated using $\pi$ photoproduction matrix elements only. These were approximated by the resonant $(M1)_3$ amplitude according to CGLN and the pole contributions to this process. In each of the 6 invariant amplitudes 2 subtractions are performed, one at infinity to include the LOW amplitude and the other at the pole $s = M^2$ making use of perturbation theory. The influence of the one-pion pole diagram in $\pi$ photoproduction not included in previous calculations is considerable. The results should be valid up to 350 Mev photon energy. (auth)

**11575** THE COVARIANT QUANTIZATION OF THE ELECTRODYNAMIC FIELD IN NON-VARYING PHOTON MASS. G. Meyer-Pundt (Universität, Freiburg i. B.). Z. Physik, 170: 131-53(1962). (In German)

It is shown that an old and well-known difficulty in quantum electrodynamics concerning the particle interpretation can be avoided. This is done by the formal introduction of a finite photon rest mass, and by using an expansion of the electrodynamic potentials into one-particle eigenfunctions instead of the usual expansion into transverse, longitudinal, and scalar waves. (auth)

**11576** PENDULUM MULTIPLICATION OF SECONDARY ELECTRONS IN THE DECIMETER WAVELENGTH RANGE. F. Kossel and K. Krebs (Universität, Berlin). Z. Physik, 170: 165-75(1962). (In German)

The conditions as deduced from theory for the existence of secondary electron resonance mechanism (dynamic multiplication of secondary electrons) are tested in the decimeter wave range. A re-entrant cavity resonator, the field length of which can be varied at its field maximum, is used. For the voltage amplitude at the start of multiplication the quadratic dependence on the length of field—as postulated by theory—is completely confirmed. For the voltage amplitude at the instant of break-off, the experiments, however, yield, for small lengths of field, higher values than calculated. (auth)

**11577** POLARIZATION MEASUREMENTS ON ELECTRON BEAMS AFTER TRANSMISSION THROUGH MAGNETIZED IRON FOILS. W. Raith and R. Schliepe (Universität, Berlin). Z. Physik, 170: 185-95(1962). (In German)

Magnetized iron foils of 500-Å thickness were penetrated by 60 kev electrons. The spin polarization of the electron beam was investigated by Mott scattering after transmis-

sion. No polarization effect was found. Since the lowest detectable polarization degree was P = 0.003 the atomic polarization cross section must be assumed to be smaller than $0.8 \times 10^{-20}$ cm$^2$. This cross section is the sum of the spin exchange cross section and the spin dependent part of the total scattering cross section. If the electron binding energy is neglected, the spin dependent part of the total scattering cross section can be calculated from the theory of Møller scattering. In the case of our conditions—60 kev and an aperture of $10^{-3}$ radian—the calculated cross section is smaller than the experimental upper limit. In further experiments the electron beam was split into the energy spectrum by an electrostatic analyzer placed between the iron foil and the Mott scattering foil. In these measurements only small parts of the energy spectrum were investigated, however, even here no detectable polarization occurred. (auth)

**11578** EFFECT OF THE PION-PION INTERACTION ON THE PION-NUCLEON SCATTERING PHASE. Klaus Dietz (Technische Hochschule, Karlsruhe, Ger.). Z. Physik, 170: 212-32(1962). (In German)

The isospin dependent part of the S-wave pion-nucleon amplitude is calculated according to the CGLN approach, but recoil and projection on the partial waves are treated exactly. Then the difference against the experimental data is approximately a constant up to 100 Mev and amounts to $\frac{1}{3}$ of the total value. It is shown that at low energies the main corrections of the CGLN equations are taken into account by a subtraction of the $\pi + \pi \rightarrow N + \bar{N}$, $J = I = 1$ amplitudes $f_1^1(t)$ as proposed by Mandelstam and Frazer. Calculations have been done for S, P, and D pion-nucleon amplitudes. The main result is a prediction of the S-wave amplitude obtained without adjusting free parameters up to 100 Mev. The relations of this method to the equations derived by Bowcock, Cottingham, and Lurié according to the Cini-Fubini approach are discussed. (auth)

**11579** ON THE QUANTUM MECHANICS OF RELATIVISTIC PARTICLES WITH DERIVED HILBERT-SPACE. Fritz Bopp (Universität, Munich). Z. Physik, 171: 90-115 (1963). (In German)

The quantum theory of relativistic particles was developed in close analogy with that of nonrelativistic ones. It is shown that the Hilbert-space for the states of a physical system can be derived immediately from experience. It happened that both theories, the relativistic as well as the nonrelativistic one belong to the same Hilbert space. Lorentz invariance does not enter until the transformations induced in the Hilbert space by the motion of the particles are considered. The transformations form a representation of the inhomogeneous Lorentz-group or even of the Klein-group of conformal transformations in space-time. The Hilbert-space was also developed from the so called "basic space." This space is spanned by simultaneously observable quantities of specific single particles which are called "simple particles." The characteristics of these single particles are: particle type (mass), momentum, spin, isotopic spin, etc. The configuration-space of a many particle system is taken as a set of all occupation numbers in the basic space. The Hilbert space is then the manifold of all square-integrable functions in the configuration space. The simple particles are considered to have zero rest-mass. Those having finite mass require the assumption of internal interactions and thus lead to complex structures. Moreover, particles of mass zero are distinguished by a higher degree of symmetry, i.e., by their invariance under transformations of the Klein-group. Taking into account further group-theoretical properties of the Klein-group, it was assumed that all particles are built up from neutrinos of two types. Only these are considered as simple particles. The case of a world with one kind of simple particles having no internal degrees of freedom was first considered. Operators are given representing the inhomogeneous Lorentz-group and the Klein-group. For particles without any interaction these can easily be determined. In the case of particles with interaction it is possible to derive all operators of the inhomogeneous Lorentz-group from the interaction energy operator. The cross-section and the wave function of the virtual state of the particle-pair, as well as the mass of a resonant state are finite. There is no bound state after a limiting process. The whole is strictly Lorentz-invariant, although the calculation was started from an expression only approximately Lorentz-invariant. The corresponding field equations are stated. The expression for interaction energy led to a strictly local coupling between the particles. However, the kinetic terms (which are bilineal in creation- and annihilation-operators) are of a non-local type, perhaps describing something like an interaction between the particles and the vacuum. (auth)

**11580** REMARKS ON KLEIN'S PARADOX. F. Beck, H. Steinwedel, and G. Suessmann (Universität, Frankfurt am Main). Z. Physik, 171: 189-98(1963). (In German)

The problem of stationary energy eigenstates of relativistic spin $\frac{1}{2}$-particles in external potentials exceeding twice the particles rest mass (Klein's paradox) was investigated, neglecting the interaction of the particles with the radiation field. This corresponded to the $H_0$ of the "bound state interaction representation" in quantum electrodynamics. For simplicity, explicit calculations are based on a one dimensional square well potential. In potentials of this type which vanish at infinity and which do not become critically singular at the origin there always exists a stationary ground state of fixed total charge. Though this state cannot be attributed to a sharp number of particles, no real paradox occurs. (auth)

**11581** A CONTRIBUTION TO THE THEORY OF THE QUASI-PARTICLE APPROACH TO THE MANY-BODY PROBLEM. E. Canel (Universität, Gottingen, Ger.). Z. Physik, 171: 250-61(1963). (In German)

The method of thermodynamic Green functions was applied to the problem of interacting fermions. Expressions for the energy and the distribution function were derived, and the concept of the quasi-particle is discussed. Within the framework of the quasi-particle approximation the de Haas van Alphen effect was considered. (auth)

**11582** LINEAR RESPONSE FUNCTION FOR QUANTUM MECHANICAL SYSTEM. J. Ranninger and W. Thirring (Univ. of Vienna). Z. Physik, 171: 312-25(1963). (In English)

The linear response function for external fields with arbitrary space-time dependence was calculated for various systems in thermal equilibrium. First general expressions were derived for free fermions and bosons. In particular the superconducting properties of free bosons were investigated. Secondly the influence of a weak repulsion between the bosons on their superconducting properties was investigated. Finally the response function for electrons with the BCS Hamiltonian was calculated exactly in the strong coupling limit. (auth)

**11583** THE THREE-BODY PROBLEM OF NUCLEAR PHYSICS. Dieter Mueller (Universität, Heidelberg). Z. Physik, 171: 371-8(1963). (In German)

For the ground state of the triton a wave function was calculated by a variational procedure assuming pure central forces between the nucleons. A method for computing

a first correction term was proposed and applied to get an estimate for the error, which was less than 3%. The three-nucleon-correlations and the charge form factor were calculated. (auth)

**11584** MAGNETISM OF THE FREE ELECTRON GAS. Peter Sigmund (Technische Hochschule, Aachen). Z. Physik, 171: 515-26(1963). (In German)

A perturbation series for the free energy of independent electrons is presented and applied to the problem of dia- and paramagnetism of the free electron gas. By using a periodic magnetic field the boundary conditions can be exactly satisfied. The results agree with those of other authors using approximate boundary conditions. (auth)

**11585** ENERGY LOSSES OF A BREMSSTRAHLUNG BEAM FROM THE ABSORBER OF A CALORIMETER. S. P. Kriiglov and I. V. Lopatin (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Tekhn. Fiz., 32: 1399-1403(Nov. 1962). (In Russian)

Bremsstrahlung energy leakage from cylindrical absorbers was studied as a function of the diameter and length of the absorber, the diameter of the beam, and bremsstrahlung maximum energy. A method was developed for determining the magnitude of the leakage under various experimental conditions. The energy removed from the absorber by the initial radiation component was evaluated. (R.V.J.)

## Neutron Physics

*Refer also to abstract 10833.*

**11586** (AAEC/TM-164) NEUTRON TEMPERATURE MEASUREMENT USING LUTECIUM. J. W. Boldeman, K. P. Nicholson, and A. Rose (Australia. Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). Nov. 1962. 9p.

Theory of neutron temperature measurement is discussed and successfully applied to measurements in two spectra. Preparation of the samples is described; samples are irradiated in HIFAR and MOATA. Activities of the lutetium-176m and lutetium-177 produced yield the temperatures. (D.C.W.)

**11587** (AE-88) CROSS SECTIONS FOR NEUTRON INELASTIC SCATTERING AND (n,2n) PROCESSES. A REVIEW OF AVAILABLE EXPERIMENTAL AND THEORETICAL DATA. M. Leimdoerfer, E. Bock, and L. Arkeryd (Aktiebolaget Atomenergi, Stockholm). Oct. 1962. 225p.

Revised edition of VDIT-50.

A survey of information on measurements and calculations on total (n,n') and (n,2n) cross sections and on angular and energy distributions of neutrons and gamma radiation produced in these processes is presented. References on nonelastic cross-section measurements were included in many cases. (J.R.D.)

**11588** (AE-98) NEUTRON STREAMING IN $D_2O$ PIPES. J. Braun and K. Randén (Aktiebolaget Atomenergi, Stockholm). 1962. 42p.

An investigation was carried out concerning the attenuation of neutrons inside $D_2O$-filled pipes penetrating a concrete shield. Pipes surrounded by an annular air gap were also considered. Thermal, epithermal, and fast neutron fluxes were measured in three separate pipes (15, 22, and 28 cm in diameter and 100 cm long) with annulii ranging from 0 to 9.7 cm in width. The thermal flux distribution was predicted theoretically by assuming it to be composed of three components originating from a fast exponential volume source and two surface sources at the origin: a 1/E-distributed source and a thermal source, of which the latter proved to be negligible. The fast flux distribution was approximated by a single exponential expression for the configuration with no annulus and with the sum of two exponentials when an annulus is present. The agreement between measured and calculated values for the thermal flux is better than a factor 1.5 after about 10 cm. For deep penetration (>40 cm) the agreement is within 20% and only the fast volume source contributes appreciably to the thermal flux. This holds for all cases both with and without annulus. The agreement in the case of the fast flux is within a factor 1.3 (>40 cm) for no annulus geometry and about 2 to 3 with annulus. Curves are presented for obtaining necessary parameters (removal cross section and extrapolated radius) for other geometries. (auth)

**11589** (HW-75526) SCATTERING LAW FOR ROOM TEMPERATURE LIGHT WATER. D. A. Kottwitz and B. R. Leonard, Jr. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Nov. 7, 1962. Contract AT(45-1)-1350. 43p.

The Hanford triple-axis crystal spectrometer is used to measure the Egelstaff scattering law for light water at 22°C for neutron wave vector changes up to 14 $Å^{-1}$ and energy transfers in the range 0.05 to 0.25 ev. The values of initial neutron energy are 0.15, 0.20, 0.30, and 0.40 ev; and scattering angles range from 4 to 72 degrees. Scattering by a vanadium sample at 77 K serves to establish the spectrometer resolution and efficiency functions. The scattering law $S(\alpha,\beta)$ and the generalized frequency distribution $p(\beta)$ derived from it are in substantial agreement in the overlap region with results obtained by Haywood and Thorson at Chalk River. The function $p(\beta)$ is extended to $\beta \approx 10$ to include the region occupied by the lowest molecular vibration level near $\beta = 8$. In this region the measured $p(\beta)$ has a low sloping plateau, indicating that the vibrational peak has been smeared out by broad instrumental resolution. The normalization integral of the measured $p(\beta)$ is higher than its theoretical value. Much data are presented. (auth)

**11590** (NP-12368) INVESTIGATION OF THE USE OF POWER SERIES METHODS FOR SOLVING THE ONE-GROUP-DIFFUSION-EQUATION WITH VARIABLE COEFFICIENTS (thesis). Robert D. Jones, Jr. (Air Force Inst. of Tech., Wright-Patterson AFB, Ohio). May 1962. 92p. (GNE/Phys/62-9)

The one-group diffusion equation with variable coefficients, which represent variable material properties within a reactor, is solved by power series methods. Solutions are obtained for an infinite slab, a sphere and a cylinder, and a sample problem is worked for the slab and cylinder. This procedure may be a valuable analytical tool for arriving at first estimates for variably loaded reactors. The solution is simple and relatively easy to obtain if the material variation is in only one dimension, if symmetry exists, and if the material variation can be accurately described by a few terms of a Taylor series expansion. If these conditions are not met, the solution becomes too detailed to be practical for hand calculation but could be handled with ease by a short digital computer program, with a few mild restrictions on the buckling term. (auth)

**11591** (NP-12370) A DESCRIPTION OF THE SORTIE I CODE. M. H. Kalos and E. S. Troubetzkoy (United Nuclear Corp. Development Div., White Plains, N. Y.). [nd]. 12p. (NDA-Phys.-1349).

A description of SORTIE I, which is designed to carry out Hauser-Feshbach calculations of inelastic neutron scat-

tering including competition from radiative capture and fission, is presented. (J.R.D.)

**11592** (NP-12480) INTRODUCTION TO SLOWING DOWN APPROXIMATIONS IN NEUTRON TRANSPORT THEORY. Research Bulletin 2. Donald H. Roy and Raymond L. Murray (North Carolina State Coll., Raleigh. School of Physical Sciences and Applied Mathematics). June 1962. 87p.

The general formulation of the neutron transport equation in the $P_L$ and $B_L$ approximations is examined in considerable detail. The first-order approximations to the general solution, viz., the ordinary and consistent $P_1$ and $B_1$ approximations, are then correlated with the various approximations treating the scattering-in term using the Greuling-Goertzel method as a basis of comparison. These first-order approximations are examined for both isotropic and anisotropic scattering in center-of-mass coordinates. The coupled set of differential equations relating the flux and slowing down density in lethargy space are reproduced for the special case of a bare reactor with sinusoidal fission source. (auth)

**11593** (PAN-354/I-A) FURTHER MEASUREMENTS OF THE ANGULAR DISTRIBUTION OF FAST NEUTRONS ELASTICALLY SCATTERED ON Ca. Stanisław Iglewski, Krystyna Maluszyńska, Ludwik Natanson, Jan Turkiewicz, and Paweł Żuprański (Polish Academy of Sciences. Inst. of Nuclear Research, Warsaw). Aug. 1962. 4p.

Earlier measurements of the angular distribution of neutrons elastically scattered on Ca were extended to neutrons in the 3 to 4 Mev energy range. The results suggest that the contribution of direct interactions increases with energy. (auth)

**11594** (SCTM-205-62(53)) THE AVERAGE NEUTRON ENERGY OF REACTOR SPECTRA AND ITS INFLUENCE ON DISPLACEMENT DAMAGE. A. D. Kantz (Sandia Corp., Albuquerque, N. Mex.). Aug. 1962. Contract [AT (29-1)-789]. 37p.

The average energy of the neutron spectrum for reactor sources may be evaluated by a threshold reaction technique using the activation of only two threshold-reaction foils. For Pu (effective threshold 0.001 Mev) and S (effective threshold 3.0 Mev) foils the average energy of a reactor spectrum is found to be $\bar{E} = 7.42\ R + 0.30$ Mev where R is the ratio of the number flux measured above the S threshold to the number flux measured above the Pu threshold. The carrier removal rate was measured for vacuum floating zone n-type S (P-doped) as a function of the average energy of the reactor spectrum as measured by the two foil method. Resistivities of 1 ohm-cm, 10 ohm-cm, and 100 ohm-cm samples were used in these irradiations at seven different reactor spectra. The carrier removal rate is found to be proportional to the average energy of the neutron spectrum. The highest average energy realized in the experimental work was 2.3 Mev. (auth)

**11595** (TID-15571) ENERGY-DEPENDENT MULTIPLE SCATTERING OF NEUTRONS IN THIN PLATES. R. O. Lane and W. F. Miller (Argonne National Lab., Ill.). Feb. 1962. Contract [W-31-109-eng-38]. 35p. (UAC-6102)

The Monte Carlo calculation described yields relative fluxes for first-, second-, and third-order elastic scattering of neutrons in thin plates. The method specifically includes the effects owing to energy loss by the neutron following elastic scattering, together with the corresponding energy dependence of the cross sections for subsequent collisions. Such effects were not included in previous treatments. Illustrative examples of typical cases are presented. (auth)

**11596** (TID-15752) A COMMENT ON THE TREATMENT OF ASYMMETRIC THIN REGIONS. Gerald P. Calame (Rensselaer Polytechnic Inst., Troy, N. Y.). [nd]. Contract [AT(30-3)-328]. 12p. (LINAC-2)

Equations are given for the net neutron currents on the left and right faces of a slab in terms of the probabilities of transmission T and reflection R in reactor calculations. The case of thin regions in asymmetric configurations is considered, e.g., a thin absorbing plate placed between a core and a reflector region to suppress a power peak. The equations are changed owing to the fact that $T_L$ and $R_L$ might be different from $T_R$ and $R_R$, respectively, and four coefficients are obtained instead of two. This problem might be approached by dividing the slab into two regions, but this approach is shown to fail because it tries to represent directional transmission in monoenergetic diffusion theory. The case where $T_L = T_R$ but $R_L \neq R_R$ is considered. (D.L.C.)

**11597** (TID-16085) TRANSIENTS IN PULSED MODERATORS. P. B. Daitch and D. B. Ebeoglu (Rensselaer Polytechnic Inst., Troy, N. Y.). Apr. 6, 1962. Contract [AT(30-3)-328]. 25p. (LINAC-3)

The time-dependent solutions of the neutron transport problem in finite moderating assemblies is considered. The time-dependent few-group P-L approximation is the basic framework for the investigation. Included are discussions of the general formulation, time transients, and water and Be examples. It is noted that, in general, the few-group time-dependent P-L approximation is quite flexible and allows the introduction of a wide variety of problems into studies with minimum accompanying complexity. (J.R.D.)

**11598** (TID-16304) THE INVESTIGATION OF NEUTRON KINETICS AND CROSS SECTIONS IN FAST NON-MODERATING ASSEMBLIES BY THE NANOSECOND PULSED NEUTRON SOURCE TECHNIQUE. L. E. Beghian, N. C. Rasmussen, R. Thews, and J. Weber (Massachusetts Inst. of Tech., Cambridge). [July 26, 1962]. Contract [AT(30-1)-2098]. 24p.

Nanosecond bursts of monoenergetic neutrons in the range 0.8–1.6 Mev are injected into non-moderating assemblies of bismuth, lead, and natural uranium. The flux in these assemblies is observed to decay exponentially with characteristic nanosecond time constants in good agreement with one velocity transport theory, and the known inelastic scattering and absorption cross sections. These experiments serve as a check on the validity of the assumptions of transport theory. The technique also serves as a method for measuring macroscopic inelastic and absorption cross sections directly, without the necessity of making the corrections required in other methods, e.g., for double scattering and for the angular distribution. (auth)

**11599** (WAPD-T-1457) SETTING THE NEUTRON CURRENT AT THE BOUNDARIES WHEN USING A DIFFUSION CODE. N. R. Williamsen (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). Apr. 1962. Contract AT-11-1-GEN-14. 12p.

A boundary-control method is described which is useful for simulating the fluxes in small regions of reactors utilizing fixed sources to provide the effect of the remainder of the reactor. The method appears to have the greatest application potential in shielding work and in reflector region irradiation experiments; however, the flux in high-multiplying regions or in cells with predetermined leakage

across boundaries can also be simulated by the method. (J.R.D.)

**11600** (WAPD-T-1490) MEASUREMENTS OF EXTRAPOLATION LENGTHS IN PULSED WATER SYSTEMS. J. A. DeJuren, R. Stooksberry, and E. E. Carroll (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). Mar. 1962. Contract AT-11-1-GEN-14. 5p.

Extrapolation lengths for cylinders of three different diameters and for one cube were measured. The cylinders were made of $\frac{1}{32}$-in. Al and were filled with water to a height equal the diameter. The surfaces were shielded. A 100-kev accelerator was used as a source of pulsed 14-Mev neutrons. The results were consistent with an extrapolation length of 0.4 cm for all cases. (M.C.G.)

**11601** THE INTEGRAL EQUATION OF THE ENERGY-DEPENDENT TRANSPORT THEORY. H. Hejtmanek (Osterreichische Hochschule, Vienna). Atomkernenergie, 7: 359-62(Oct. 1962). (In German)

The theory of neutron spectra uses the Boltzmann integro-differential equation. In the case of plane geometry one usually develops the solution into Legendre functions. The integral equation of the transport problem is found, collision kernel for elastic collision is examined, and then a general method for getting the solution of this equation is presented. (auth)

**11602** THE EFFECT OF ROTATIONAL FREEDOM IN SEVERAL AMMONIUM SALTS AND DIMETHYL ACETYLENE ON THE INELASTIC SCATTERING OF SLOW NEUTRONS. J. J. Rush, G. J. Safford, T. I. Taylor, and W. W. Havens, Jr. (Columbia Univ., New York and Brookhaven National Lab., Upton, N. Y.). Nucl. Sci. Eng., 14: 339-45 (Dec. 1962). (BNL-6042)

Slow-neutron total cross sections for polycrystalline $NH_4PF_6$, $(NH_4)_2S_2O_8$, and $(NH_4)_2CrO_4$ are measured at 80 and 296°K as a function of neutron wavelength. In addition cross sections are measured at 23°C for $NH_4SO_3F$ and $CH_3C \equiv CCH_3$. Cross sections vs. temperature for $NH_4PF_6$ and $(NH_4)_2S_2O_8$ are also obtained at $\lambda_n = 8$ Å (0.0015 ev) from 80°K to room temperature. The long-wavelength slopes in barns/Å of the scattering cross sections per hydrogen atom at 23°C are: $NH_4PF_6$, 12.7; $(NH_4)_2S_2O_8$, 9.6; $NH_4SO_3F$, 10.0; $(NH_4)_2CrO_4$, 5.5; $CH_3C \equiv CCH_3$, 12.4. The slope for $NH_4PF_6$ approaches that for free $NH_3$ gas, indicating a rotational barrier of ~0.2 kcal/mole for the ammonium ion. The high slope for $CH_3C \equiv CCH_3$ indicates a low barrier to rotation of the methyl groups in this compound. The lower slopes for $(NH_4)_2S_2O_8$ and $NH_4SO_3F$ show that the ammonium ions in these compounds have higher barriers of the order of 0.7 to 1 kcal/mole. Slopes measured at 80°K are: $NH_4PF_6$, 2.5 b/Å-H; $(NH_4)_2S_2O_8$, 1.0 b/Å-H; $(NH_4)_2CrO_4$, 0.0 b/Å-H. In addition the cross section vs. temperature curve for $NH_4PF_6$ indicates no abrupt change in rotational barrier down to 80°K. These low temperature results show the presence of significant rotational freedom in $NH_4PF_6$ even at 80°K. The presence of rotational states at low temperature for exchange of energy with neutrons, together with the comparatively low absorption cross sections, make ammonium salts such as $NH_4PF_6$ ($N^{15}$-enriched) and methyl-substituted compounds like $CH_3C \equiv CCH_3$ of interest as moderators for cold neutron sources. (auth)

**11603** RENEWAL THEORY AND THE SLOWING DOWN OF NEUTRONS. Coleridge A. Wilkins (Univ. of New South Wales, Kensington, Australia). Nucl. Sci. Eng., 14: 346-57(Dec. 1962). (AAEC/TM-136)

Probability methods are applied to the problem of the slowing-down of neutrons, and attempts are made to provide a framework both for the exposition and computation of various phenomena in this field. It is shown that under certain conditions, the slowing-down of neutrons is a renewal process and renewal theoretical results apply. For instance, if scattering is isotropic and all cross sections similarly varying, then (in lethargy) slowing-down is certainly a renewal process. After investigating some aspects of moderation in hydrogen, and some incidental extensions of results for hydrogen, it is shown that for renewal types of slowing-down from a monoenergetic source, the Laplace transform of the moments of the number of collisions at lethargies below u may be obtained by differentiating (with respect to t) a particular generating function. This derivative form applies to some types of anisotropic scattering as well as to isotropic scattering. The expressions derived are then extended to a distributed source by a method from reactor theory, and some resulting expressions are checked against corresponding renewal formulas. The asymptotic distribution of the number of collisions to slow down is found from renewal theory, from which it is shown that when scattering is isotropic, the spread of the number of collisions to thermalize in a light moderator is relatively greater than in a heavy moderator. The asymptotic form of the density of nth collisions is investigated. The theory is applied to a particular case of anisotropic scattering, which occurs above about 100 kev. An exact expression is obtained (for similarly varying cross sections and zero absorption) for the probability that, in a mixture of n species, a neutron has r collisions at lethargies below u, precisely k of which are with a given species. The given species is then taken to be very heavy and the exact expression approximated accordingly. (auth)

**11604** RESONANCE ABSORPTION IN MATERIALS WITH GRAIN STRUCTURE. R. K. Lane, L. W. Nordheim, and J. B. Sampson General Atomic Div., General Dynamics Corp., San Diego, Calif.). Nucl. Sci. Eng., 14: 390-6(Dec. 1962).

The problem of resonance absorption is investigated for materials in which the absorber is lumped in small grains imbedded in a matrix of moderator. The grains themselves are taken as the fundamental elements in heterogeneous geometry. It is important to treat correctly the mutual shielding between the grains, that is, the Dancoff correction. Introduction of this correction solves immediately the case of macroscopically homogeneous assemblies. The result can be expressed in terms of "shielded" cross sections for the lumped absorber. Utilization of this concept permits the treatment of additional macroscopic heterogeneities. Conventional calculational methods can be employed if the macroscopic heterogeneities are treated with the help of the equivalence relations, and this procedure permits an adequate comparison between the grain-structured and homogeneous compounds. Numerical examples are given. The average shielding is nearly linear in the grain size. For grains of $ThO_2$ in a graphite matrix, the reduction is about 15% for grains of 0.06 cm diam. On the other hand, the temperature derivative of the resonance integral is increased slightly, particularly at higher temperatures. Therefore either the Doppler coefficient of reactivity may be maintained with a reduced resonance absorption or the Doppler coefficient may be increased for the same resonance absorption. (auth)

**11605** A NEW METHOD FOR MEASURING THERMALIZATION PARAMETERS. E. Friedman (Hebrew Univ., Jerusalem). Nucl. Sci. Eng., 14: 420-2(Dec. 1962).

An infinite homogeneous moderator having 1/v absorption is considered that contains a small amount of non-

1/v absorber. A method is described for measuring the neutron thermalization parameters of this moderator, based on the analysis of several independent measurements using phenomenological parameters. The distortion of a Maxwellian neutron spectrum by the non-1/v absorber is taken as one of the parameters of the method. The relation of the infinite-medium parameters to those measured in a finite system is shown. The moderating properties of the 1/v and the non-1/v absorbers are found to be separable from one another. (T.F.H.)

**11606** QUASI-CLASSICAL APPROXIMATION IN NEUTRON SCATTERING. G. Kosaly (Central Research Inst. of Physics, Bidapest) and R. E. Turner. Phys. Letters, 2: 266-8(Oct. 15, 1962). (In English)

A proof of the Schofield time shift in the classical approximation was recently given (Turner, R. E., Physica 27(1961)260). Although the proof as given was correct, the statement was also made that the time shift took full account of the recoil of the atom, higher order corrections only affecting the statistics of the scattering system. That this statement is incorrect may be seen by considering the harmonic oscillator. This problem can be solved exactly, and it is found that the time shift, which is of order $\hbar$, is not sufficient to take into account the recoil of the atom. The source of the error and the correct expression to all orders in $\hbar$ are pointed out. (W.D.M.)

**11607** SCATTERING OF SMALL-WAVELENGTH NEUTRONS BY A SQUARE-MOUND-POTENTIAL GAS. G. H. A. Cole (Clarke, Chapman and Co. Ltd., Gateshead, Eng.). Phys. Rev., 129: 1005-9(Feb. 1, 1963).

The modern theory of classical fluids, using the Born-Green-Yvon equation and a modified form of the Kirkwood superposition approximation involving powers of the particle number density n, is used to investigate the total neutron elastic scattering cross section for high-energy neutrons and heavy nuclei any pair of the latter of which interact according to the repulsive square mound potential. This potential function is defined by $\psi(r) = \epsilon$ $(r \leq 1)$ and $\psi(r) = 0$ $(r > 1)$, where $\epsilon$ is a positive constant, r is the separation distance, and the particle diameter is taken as the unit of distance. If T is the absolute temperature, k the Boltzmann constant, and $z = 1 - \exp\{-\epsilon/kT\}$, then it is found by the present arguments for the low-density gas limit, where a number density expansion is valid, that up to the cube power of the density where $\sigma_{tot} = 1 - (\lambda^2/2\pi)[zn + I_1(z)n^2 + I_2(z)n^3]$; $I_1(z) - 3.1416z^2 + 2.6834z^3$; $(1 + 0.1563z)I_2(z) = 6.2755z^3 - 20.2741z^4 + 19.0949z^5 - 4.7807z^6$, and the undefined symbols have their usual meaning. (auth)

**11608** DETERMINATION OF NEUTRON FLUX-ENERGY DISTRIBUTION BY ACTIVATION AND TRANSMISSION. M. Sabeu and I. Zamfiresku (Inst. of Nuclear Physics, Bucharest). Rev. Phys. Acad. Rep. Populaire Roumaine, 7: 39-44(1962). (In Russian)

Small-dimension activation foils that induce only a negligible local disturbance were used for determining neutron flux distributions in a reactor and thermal column. (R.V.J.)

**11609** SELF-SHIELDING COEFFICIENT FOR THICK GOLD FOILS IN RESONANCE NEUTRON ACTIVATION. V. Khristov and M. Sabeu (Inst. of Nuclear Physics, Bulgarian Academy of Sciences, Bulgaria). Rev. Phys., Acad. Rep. Populaire Roumaine, 7: 101-6(1962). (In Russian)

An approximate evaluation is made of self-shielding in the case when neutron incidence is normal to the irradiated foil surface. The results were verified by experimental measurements on gold foils in a reactor channel. Data on $Au^{198}$ $\gamma$ activity, measured with a scintillation counter and extrapolated, are tabulated. (R.V.J.)

**11610** DEPOLARIZATION AND SMALL-ANGLE SCATTERING OF NEUTRONS BY LATTICE DEFECTS IN FERROMAGNETIC CRYSTALS. H. Kronmueller, A. Seeger, and M. Wilkens (Max-Planck-Institut für Metallforschung, Stuttgart and Technische Hochschule, Stuttgart). Z. Physik, 171: 291-311(1963). (In German

Investigations were made of dislocation arrangement with the help of polarized neutrons. In ferromagnetic metals the magnetization surrounding the dislocation is inhomogeneous on account of the magnetoelastic coupling. This inhomogeneity causes small-angle scattering of the neutrons and a spin reversal of the scattered neutrons. The magnetic scattering was found to be about a factor of 100 greater than the corresponding scattering on volume dilation of the dislocations. The scattering cross section is dependent on the evolved dislocation arrangement sensitivity to irradiation direction. The measurements allowed detailed statements to be made concerning the distribution of dislocations in plastically deformed crystals. (tr-auth)

## Nuclear Properties and Reactions

*Refer also to abstract 10506.*

**11611** (AD-277387) MESON PRODUCTION IN THE INTERACTIONS OF 26.7 Gev/c PROTONS WITH EMULSION NUCLEI. Y. K. Lim (Illinois. Univ., Urbana). [1962]. Contract Nonr-183405. 45p.

One-hundred-thirty-three interactions initiated in nuclear emulsions by 26.7 Bev/c protons are studied. The events are subject to separation into two groups, one in which most of the shower particles are emitted in a single nucleon-nucleon collision in the target nucleus, the other in which multiple collisions produce the particles. Experimental procedure, classification of events, identification of tracks, and various distributions are discussed. Graphs of distributions are included. (27 references.) (D.C.W.)

**11612** (AFOSR-2975) INVESTIGATION OF NUCLEAR REACTIONS INDUCED BY HEAVY ION BOMBARDMENT AND OF EXCITED LEVELS IN HEAVY NUCLEI. Ingmar Bergstroem and Bjoern Åstroem (Sweden. Kungliga Vetenskapskademien. Nobelinstitutet for Fysik, Stockholm). June 15, 1962. Contract AF61(052)-118. 19p. (AD-278240)

The following work is reported: (1) Angular correlations in (alpha,p)- and (alpha-alpha')-reactions at 14 Mev. (2) Heavy ion-induced reactions and properties of light astatine isotopes formed in those reactions. (3) Study of energy levels, transition probabilities, etc. in several isotopes mostly in the lead region, excited in radioactive decay. (4) Stopping of heavy ions in various materials. (5) New instruments and methods: (a) automatic gain controlled amplifier, (b) use of CRT oscilloscopes in time- and pulse-height measurements, (c) time to pulse-height converter, (d) surface barrier semiconductor detectors. (auth)

**11613** (BNL-768) NEUTRON CROSS SECTION EVALUATION GROUP. Newsletter No. 7. Sophie Moore (Brookhaven National Lab., Upton, N. Y.). Oct. 1962. Contract [AT(30-2)-Gen-16]. 14p.

A bibliography of 20 Russian articles on neutron cross sections is presented. Where the data are in tabular form, they are presented; however, graphs are not included. (D.L.C.)

**11614** (BNL-6044) CROSS SECTIONS OF 14.5 Mev NEUTRON REACTIONS WITH SPECIAL INTEREST IN $Ca^{47}$ FORMATION. Manny Hillman (Brookhaven National Lab., Upton, N. Y.). [Mar. 6, 1962]. Contract [AT(30-2)-Gen-16]. 12p.

The cross sections of the $Ti^{50}(n,\alpha)Ca^{47}$ and $Ca^{48}(n,2n)Ca^{47}$ reactions for 14.5 Mev neutrons are measured as 10 ± 2 mb and 0.9 ± 0.2 b, in good agreement with the calculated values. The cross sections of the $Ti^{48}(n,p)Sc^{48}$ and $Ti^{47}(n,p)Sc^{47}$ are measured incidentally as 55 ± 11 and 99 ± 20 mb, respectively, in fair agreement with some literature values. The cross section obtained for the $V^{51}(n,\alpha)Sc^{48}$ reaction, 18 ± 3 mb, does not agree with results in the literature. (auth)

**11615** (BNL-6082) OBSERVATION OF THE $Li^6(n,\alpha)H^3$ REACTION BY ELECTRON MICROSCOPY OF $Li^6F$ FILMS. J. J. Kelsch, O. F. Kammerer (Brookhaven National Lab., Upton, N. Y.); and A. N. Goland (Watertown Arsenal, Mass.). [1962]. Contract [AT(30-2)-Gen-16]. 8p.

To gain insight into the energy transfer mechanisms that produce tracks in thin films and in thinned bulk metals, tracks produced in LiF films by exposure to thermal neutrons are observed by electron microscopy. Calculations of LiF stopping power for the alpha and triton in the reaction $Li^6(n,\alpha)H^3$ show the triton should have a range six times that of the alpha particle. (D.C.W.)

**11616** (BNL-6166) THE Pb X-RAYS THAT ACCOMPANY $Po^{210}$ DECAY: MEASUREMENT OF THE M PHOTON YIELD, AND THEORY. William Rubinson (Brookhaven National Lab., Upton, N. Y.). [1960]. Contract [AT(30-2)-Gen-16]. 46p.

The probability that a Pb M photon is emitted in the alpha decay of a $Po^{210}$ atom is $0.91\ (\pm 15\%) \times 10^{-3}$ photons per alpha, as measured by means of a proportional counter and pulse-height analyzer. This value is in gross disagreement with theoretical estimates. A Pb M spectrum from $Po^{210}$ decay shows definite differences from a conventional spectrum, indicating extensive ejection of the outermost electrons in the decay act. In particular, the spectrum from $Po^{210}$ contains a 3.7 kev line, whose intensity is about 4% of the total spectral intensity, and whose energy is consistent with the allowed, but hitherto unreported, transition $M_I O_{II,III}$. The theory of electron ejection in alpha decay is reworked and the results are compared with the measured values of K, L, and M ejections in $Po^{210}$ decay. It is concluded that: 1) the apparent agreement between the measured probability of K ejection and the theoretical calculations of Migdal and of Schaefer is fortuitous, and that for K, as well as L and M ejections, there is an order-of-magnitude discrepancy between theory and experiment; 2) the failure of the theory can be ascribed in large part to an unjustifiable use of hydrogenic wave functions. (28 references.) (auth)

**11617** (BNL-6205) SECOND ORDER EFFECTS OF NUCLEAR MAGNETIC FIELDS. Morton M. Sternheim (Brookhaven National Lab., Upton, N. Y.). June 14, 1962. Contract [AT-30-2-GEN-16]. 8p.

By using the Dirac equation, the contributions to atomic levels of terms quadratic in A are considered, where A may be, for example, the nuclear magnetic dipole field. A consistent quantum mechanical treatment is shown to cancel all terms arising from $[A_i, A_j] \neq 0$, thereby resolving a disagreement between hyperfine structure corrections calculated nonrelativistically and relativistically. (auth)

**11618** (BNL-6647) PENETRATION EFFECTS IN MAGNETIC-DIPOLE L-SHELL INTERNAL CONVERSION. Internal Report. E. L. Church (Frankford Arsenal, Philadelphia) and J. Weneser (Brookhaven National Lab., Upton, N. Y.). Sept. 1962. Contract [AT(30-2)-Gen-16]. 11p.

Internal conversion coefficient and penetration parameters associated with K and L shell ICC transitions are discussed. It is concluded that K and L Icc's of 279 kev transitions in thallium-203 cannot be understood in the absence of penetration effects. K and L shell coefficient analysis suggests a value ~8 for the penetration parameter but does not exclude a value of 75. (D.C.W.)

**11619** (CEA-2172) ENERGIE CALORIFIQUE D'ORIGINE NUCLEAIRE DEGAGEE DANS LES MATERIAUX NON FISSILES (theses). (Thermal Energy of Nuclear Origin Produced in Non-Fissile Materials (thesis)). P. Millies, J. Berger (France. Commissariat à l'Énergie Atomique. Centre d'Etudes Nucléaires, Grenoble); and G. Naudet (France. Commissariat à l'Énergie Atomique. Centre d'Etudes Nucléaires, Saclay). 1962. 81p.

Description is given of the interaction phenomena between elementary particles and material that may be observed during the irradiation process in a nuclear reactor: nuclear reactions due to neutrons, production of gamma rays and absorption of those gamma rays through various processes. The phenomena producing thermal energy in irradiated material are then quantitatively examined, and the results are summed up in a formulary. Tables and figures giving all the numerical values necessary for practical calculations are included. (auth)

**11620** (EANDC(E)-10.U) MEASUREMENT OF THERMAL ABSORPTION AND SCATTERING CROSS SECTIONS OF NATURAL NEON. R. Genin, H. Beil, R. Joly, and M. Ribrag (France. Commissariat a l'Energie Atomique. Centre d'Etudes Nucleaires, Saclay). [1959]. 4p.

The total cross section measurement of neon makes it possible to determine the scattering cross section $\sigma_s$ and an upper limit of the absorption cross section $\sigma_a$ for 2200 m/sec neutrons. The results obtained are $\sigma_s = 2.38 \pm 0.04$ b and $\sigma_a \leq 50$ mb. (auth)

**11621** (KAPL-M-HME-6) ABUNDANCE OF THE 1.43 Mev GAMMA RAY OF CESIUM-138. H. M. Eiland and A. F. Heitkamp, Jr. (Knolls Atomic Power Lab., Schenectady, N. Y.). Oct. 17, 1962. Contract W-31-109-eng-52. 14p.

Use of cesium-138 as a fission product monitor in reactors is hampered by the indeterminacy of the abundances of gamma rays used to calculate its absolute activity. Decay rates measured by gamma scintillation spectrometry differ from rates derived from beta counting, the source of error seeming to lie in the abundance value of the 1.43 Mev gamma used. A redetermination yields a value of 74 ± 5% that agrees well with the previous value of 73 ± 7%. (D.C.W.)

**11622** (NP-12439) DETERMINACION DEL FACTOR DE ABSORCION $f_S$ Y DE LOS FACTORES $f_\gamma$ Y $f_W$ EN MUESTRAS DE KI. INFORME NO. 27. (Determination of the Absorption Factor $f_S$ and of the Factors $f_\gamma$ and $f_W$ in KI Samples. Report No. 27). J. Escudero and E. Stuardo (Chile. Universidad, Santiago. Instituto de Fisica y Matematicas). July 1960. 6p.

Measurement of the $\beta$ decay of $I^{128}$ in the form of KI using a G-M counter is dependent on many factors. The methods used for the determination of the absorption factor and of $f_\gamma$ and $f_W$ are described, and the experimental results are shown graphically. (J.S.R.)

**11623** (NP-12496) EXCITED STATES IN $N^{14}$ FROM $C^{12}$ + d REACTIONS. G. S. Mani, F. Picard, A. Sadeghi

(France. Commissariat a l'Energie Atomique. Centre d'Etudes Nucléaires, Saclay); and J. M. F. Jeronymo (Rio de Janeiro. Centro Brasileiro de Pesquisas Físicas). 1962. 14p. (Notas de Fisica, Vol.X, No. 1).

Reactions (d,d), (d,$p_0$), (d,$p_1$)(d,$p_2$), and (d,$p_3$) in carbon-12 are examined to obtain the energy levels in nitrogen-14 from 11-15 Mev excitation. Excitation curves for the reactions at angles 143.5 and 155° are shown for deuteron energies from 0.9 to 5.0 Mev. Levels of nitrogen-14 obtained are compared to other experimental results, and speculation on possible reaction processes is included. (D.C.W.)

**11624** (NYO-10386) COMPARISON BETWEEN NUCLEAR REACTIONS OF ALPHA PARTICLES WITH SCANDIUM-45 AND DEUTERONS WITH TITANIUM-47. Katherine Lee Chen (Columbia Univ., New York). May 1962. Contract [AT(30-1)-1019]. 65p. (CU-32-62-AEC-1019-Chem)

The excitation functions for the ($\alpha$,n), ($\alpha$,2n), ($\alpha$,2p), ($\alpha$,$\alpha'$n)$^m$, ($\alpha$,$\alpha'$n)$^g$, and ($\alpha$,2pn) reactions of scandium-45 and the (d,n), (d,2n), (d,2p), (d,$\alpha$n)$^m$, and (d,$\alpha$n)$^g$ reactions of titanium-47 are measured for alpha energies from 15 to 40 Mev and for deuteron energies from 4 to 20 Mev. Since the reactions, $\alpha + Sc^{45}$ and $d + Ti^{47}$, proceed through the same compound system, excitation functions from these two reactions are compared on the basis of the compound nucleus theory. Using this theory, excellent agreements are obtained for the alpha-particle induced reactions. However, for the deuteron induced reactions, the compound nucleus contributions are only about one-third to one-half of that in the alpha-particle induced reactions. Non-compound processes are found to make substantial contributions in the (d,2n) and (d,2p) reactions. Reaction, cross sections and excitation functions are displayed and discussed, and agreement with theory is examined. (auth)

**11625** (PAN-204) ELASTIC AND INELASTIC SCATTERING OF 12.8 Mev DEUTERONS ON $^{27}$Al NUCLEI. H. Niewodniczański, J. Nurzyński, and J. Wilczński (Polish Academy of Sciences. Inst. of Nuclear Physics, Krakow). Aug. 1962. 6p.

Angular distributions for elastic and inelastic scattering of 12.8 Mev deuterons on aluminum-27 nuclei have been measured. A magnetic spectrometer with the energy resolution of 150 kev has been used. Measured angular distributions corresponding to several states of the aluminum-27 nucleus have been fitted with theories of diffraction scattering. Shape and value of differential cross sections are also investigated. (auth)

**11626** (PUC-1962-89) SHELL MODEL ANALYSIS OF THE LEVEL STRUCTURE OF $Ar^{41}$. Y. Shadmi (Inst. for Advanced Study, Princeton, N. J.) and I. Talmi (Princeton Univ., N. J. Palmer Physical Lab.). Aug. 1962. Contract [AT(30-1)-937]. 26p.

Levels of $Ar^{41}$ experimentally observed up to excitation energy of 4.5 Mev are considered. Using experimental data from neighboring nuclei the positions of 40 odd parity states are calculated in the framework of the shell model. Good agreement is obtained for the low lying levels. Approximate treatment of the $d_{\frac{3}{2}}^2 f_{\frac{7}{2}}^2 p_{\frac{1}{2}}$ and $d_{\frac{3}{2}}^2 f_{\frac{7}{2}}^2 p_{\frac{3}{2}}$ configurations in addition to the $d_{\frac{3}{2}}^2 f_{\frac{7}{2}}^2$ ground configuration gives a semiquantitative account of all $\frac{3}{2}$- and $\frac{1}{2}$-levels up to 4.5 Mev. Many odd parity levels with $J > \frac{9}{2}$ that were not yet found experimentally are predicted to be in this region. Tables of observed and calculated levels for various J values and tables of matrices of the $d_{\frac{3}{2}} - f_{\frac{7}{2}}$ interaction energy for different J values are included. (auth)

**11627** (TID-15088) FINAL REPORT OF NEUTRON CROSS-SECTIONS AND NUCLEAR SPECTROSCOPY. Larry Schecter (Oregon State Coll., Corvallis). [Feb. 15, 1962]. Contract AT(45-1)-1372. 36p.

A fast delayed coincidence spectrometer built at Oregon State University is described, and the operation of some of its electronic components is discussed. Calibration of the spectrometer for fast pulse shaping, with artificial pulses and with nuclear pulses from gamma decay of copper-64 and cobalt-60 is explained. Calibration curves are included, and use of the spectrometer in neutron time-of-flight cyclotron beam pulse studies as well as in investigation of the use of the cyclotron as a neutron source is reported. The arrangements used in these experiments are diagrammed. In addition, the directional correlation between the 1.119-Mev gamma ray and the 0.885-Mev gamma ray in the de-excitation of excited titanium-46 is measured to study the spin and parity assignment of the 2.004-Mev state as well as the mixing ratio of multipolarities in the upper transition. Procedure is described, and an assignment of (4+) for the 2.004-Mev state is made. Inclusion of at most 0.005 ± 0.002% M3 radiation mixed with pure E2 in the 1.119-Mev gamma ray is noted. (D.C.W.)

**11628** (TID-15849) MEASUREMENTS OF LIFE-TIMES OF RADIOACTIVE SOURCES. J. E. Monahan, S. Raboy, and C. C. Trail (Argonne National Lab., Ill.). Apr. 1962. Contract W-31-109-eng-38. 19p. (UAC-6285)

The measurement of the intensity of gamma rays as a function of time was used to determine decay times and branching ratios of some radioactive sources. The half lives of $Cl^{38}$, $K^{42}$, and $Na^{24}$ were measured to be 37.12 ± 0.18 min, 12.47 ± 0.07 hr, and 15.05 ± 0.05 hr, respectively. In the decay of $Cl^{38}$, the $\beta$ branch to the 2.1-Mev state in $A^{38}$ has 0.29 ± 0.06 times the intensity of the branch to the 3.7-Mev level. (auth)

**11629** (TID-15884) A TECHNIQUE FOR MEASURING THE NEUTRON CAPTURES IN $U^{235}$ AND NATURAL BORON. D. A. Gavin, D. J. Anthony, R. F. Ruane, and P. J. Tetrault (Knolls Atomic Power Lab., Schenectady, N. Y.). [1961?] Contract [W-31-109-eng-52]. 40p.

A technique is described for determining the neutron captures in boron and $U^{235}$. The technique is based on a calibration of the (n,$\gamma$) reaction produced by neutron capture. In fuel the $\gamma$ activity is emitted from fission fragments, while in the poison, the $\gamma$ activity comes from a small amount of manganese mixed homogeneously with the boron. The technique is applied to the determination of neutron capture profiles through the fuel region of a slab core into a centrally located poison septum. A comparison is made between the experimental results and a calculational analysis. (auth)

**11630** (TID-15924) CLASSICAL DESCRIPTION OF DEUTERON STRIPPING IN A COULOMB FIELD. Richard H. Lemmer (Massachusetts Inst. of Tech., Cambridge and Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). [1959]. Contract AT(30-1)-2098. 11p.

A simple calculation of the angular distribution of deuteron stripping reactions in the Coulomb field of a heavy nucleus is made on the basis of a semiclassical representation of the motion. The classical distributions are compared favorably with more exact quantal stripping angular distributions. An expression of the cross section is also included. (D.C.W.)

**11631** (TID-16049) EVAPORATION NEUTRONS FROM PROTONS ON RHODIUM. C. H. Holbrow and H. H.

Barschall (Wisconsin. Univ., Madison). [nd]. Contract [AT(11-1)-Gen-7]. 7p.

Spectra of neutrons from the bombardment of rhodium with protons were studied at bombarding energies between 5 and 12 Mev and neutron emission angles up to 140°. Neutron energies were measured by time-of-flight spectrometry. Data are presented in graphs. (M.C.G.)

**11632** (TID-16202) ALPHA HALF-LIVES OF $Po^{216}$, $At^{217}$ AND $Rn^{218}$. Herbert Diamond and James E. Gindler (Argonne National Lab., Ill.). May 1962. Contract [W-31-109-eng-38]. 18p. (UAC-6413)

Reports of an abnormally fast decay rate for astatine-217 and variation of the radon-218 half life from theoretical relations encourage a new measurement of these half lives. Polonium-216 is also examined since its half life can be used to check the equipment. The method of preparing the samples and the electronic equipment used are described. Data are presented and discussed, and the half life values obtained are compared with other determinations. Values of 0.145 ± 0.002, 0.0323 ± 0.0004, and 0.035 ± 0.001 sec are reported for polonium-216, astatine-217, and radon-218, respectively. (D.C.W.)

**11633** (TID-17534) NUCLEAR PHYSICS RESEARCH. Final Report, November 1, 1950–September 30, 1962. J. C. Harris, D. F. Herring, and K. W. Jones (Ohio State Univ. Research Foundation, Columbus). Dec. 1962. Contract AT(11-1)-147. 27p.

Results of work on particle interactions done during the period 1951 to 1962 are outlined. It is noted that details concerning work under the contract for this period are described in previously issued progress reports. The work during the period from 1951 to 1957 was devoted mostly to the study of (p,γ) reactions and proton stopping cross sections. During the period 1957 to 1961, the accelerator was moved and rebuilt. The work since 1961 was concentrated on the measurement of elastic cross sections for $N^{14}(d,d)N^{14}$ and $O^{16}(d,d)O^{16}$ and on polarization of neutrons from the $N^{14}(d,n_0)O^{15}$ reaction. (J.R.D.)

**11634** (TID-17696) NUCLEAR REACTION STUDIES A. RANGES OF LOW-ENERGY RECOILS. B. CHARGE-STATES OF LOW-ENERGY RECOILS. C. RADIATIVE DEUTERON CAPTURE. D. ISOMER RATIOS FROM (d,p) REACTIONS. Annual Report, January 9, 1962 to January 9, 1963. Robert L. Wolke (Pittsburgh. Univ. Wherrett Lab. of Nuclear Chemistry). Contract AT(30-1)-2771. 39p.

Detection and energy resolution of recoil nuclei from 15-Mev deuteron-induced reactions are studied. The effects of detector bias voltage variation, absorbers before the detector, and target thickness variations on detection and resolution are examined, and data obtained are displayed. Recoil range-energy measurements and the resultant data are also included. Charge-state distribution measurements are being performed with a magnetic deflection apparatus (described). Graphs and tables display data on reactions on carbon-12 and carbon-13. Work on radiative deuteron capture by tungsten isotopes producing rhenium 188 and $188^m$ is also discussed. The cross section for the tungsten-186 (d,γ) reaction is found to be below the limit of sensitivity of the method used. Similar work with silicon-28 is still being analyzed. Isomer yield ratios from deuteron-induced reactions are being continued, and descriptions of target preparation and equipment are presented. (D.C.W.)

**11635** (TID-17720) NUCLEAR REACTIONS IN LIGHT NUCLEI. Annual Report. (Johns Hopkins Univ., Baltimore). Sept. 1962. Contract AT(30-1)-2028. 144p.

Separate abstracts have been prepared for seven papers included on particle interactions and nuclear reactions in light nuclei. (D.C.W.)

**11636** (TID-17720(p.8-14)) STUDY OF THE NEUTRONS FROM THE REACTION $F^{19}(d,n)Ne^{20}$. Roger W. Finlay and George E. Owen (Johns Hopkins Univ., Baltimore).

Angular distributions of neutrons corresponding to transitions to the ground and first (1.63-Mev) excited states in the reaction $F^{19}(d,n)Ne^{20}$ are measured at incident deuteron energies of 1.0 and 1.3 Mev. Neutrons are detected using a single stilbene crystal spectrometer. Pulse shape discrimination in stilbene is employed to eliminate background radiation. The angular distributions of the ground state neutrons are consistent with the predictions of nuclear stripping theory when exchange terms are incorporated in the analysis. (auth)

**11637** (TID-17720(p.15-37)) MEASUREMENTS OF NUCLEAR POLARIZATION IN THE $B^{11}(d,p)B^{12}$ REACTION. P. W. Keaton and Leon Madansky (Johns Hopkins Univ., Baltimore).

The nuclear polarization occurring in the $B^{11}(d,p)B^{12}$ reaction is observed by studying the asymmetry of the electrons emitted by boron-12. Boron-12 nuclei are produced by bombarding boron on a tantalum ribbon with 2.8-Mev deuterons. Apparatus used in this and similar experiments is discussed, particularly the electronics system. Data for recoil boron-12 nuclei collimated at ± 53 degrees and stopped by xenon and polyethylene foils are presented for comparison with other results and discussed. A polarization of about $-0.03$ $(\vec{K}_D \times \vec{K}_p)$ is observed. (D.C.W.)

**11638** (TID-17720(p.38-61)) NEUTRON SPECTROSCOPY. Erich Willen (Johns Hopkins Univ., Baltimore).

A circuit used to study ground and first excited states of neutrons in the reaction $F^{19}(d,n)Ne^{20}$ makes use of the difference in pulse shapes of heavy, positive particles and light, negative particles in organic scintillation crystals. Modifications that permit the extension of measurements to 3 Mev are made, and the system is tested on the reaction $B^{11}(d,n)C^{12}$. Detection of unwanted gammas and electrons is noted and corrected, and problems met with the electronics system are discussed. The Fortran program to interpret proton recoil spectra from stilbene is also examined, and the processing of data is described with representative computer data being shown. Improvements on the fast circuitry for time-of-flight measurements are explained, and various diagrams are presented. (D.C.W.)

**11639** (TID-17720(p.62-78)) PROPOSED STUDIES OF THE POLARIZATION OF THE PROTONS FROM THE $B^{11}(d,p)B^{12}$ REACTION. Richard Tisinger (Johns Hopkins Univ., Baltimore).

In studying the polarization of protons from the reaction $B^{11}(d,p)B^{12}$, a beam of 3-Mev deuterons strikes a boron target; and the resultant protons strike a mylar scattering foil. A computer will determine left-right asymmetry due to the geometry of the apparatus. A program using non-relativistic kinematics to obtain design parameters for the analyzer used in the experiment is shown and equations used in the program are derived. A program for associating product particles from the same reaction is also shown, and representative data cards are displayed. (D.C.W.)

**11640** (TID-17720(p.79-89)) PRODUCTION OF POLARIZED BEAMS USING METASTABLES. Leon Madansky (Johns Hopkins Univ., Baltimore).

Production of polarized beams for accelerators by taking advantage of the properties of metastable states of atoms is investigated. Introduction of positive ions into a gas produces metastable (2S) states that then receive charge by transfer giving a metastable beam with the initial ion beam's energy and geometry. In magnetic fields the four states of the singlet and triplet metastable 2S split giving states that can be quenched and leaving states that contain 50% nuclear polarization. Preferential ionization of this state yields ions that are consequently ionized. Use of metastable states of hydrogen and helium is treated, and the equipment involved is described. (D.C.W.)

**11641** (TID-17720(p.90-7)) FEASIBILITY INVESTIGATION OF A TEST OF THE FEYNMANN-GELL-MANN THEORY OF $\beta$-DECAY. David Goldberg (Johns Hopkins Univ., Baltimore).

The Feynmann–Gell–Mann conserved isovector current theory of weak interactions predicts corrections to the matrix elements for $\beta$ decay accompanied by inner bremsstrahlung. One of these corrections is a so-called "weak magnetism" term. The possibility of confirming these predictions is examined. Investigation based on angular correlation of simultaneous beta and gamma emission is shown to be infeasible due to low counting rates, and calculation of the effect of the "weak magnetism" correction indicates that its effect would not be observable on the shape of the beta or gamma spectra. Beta and gamma spectra are shown as well as the transition matrix elements, numerical integrations, and integrated spectra. (D.C.W.)

**11642** (TID-17720(p.98-100)) PROPOSAL FOR A SEARCH FOR LEPTON PAIRS. R. Zdanis, Leon Madansky, et al. (Johns Hopkins Univ., Baltimore).

An experiment to detect mu meson (lepton) pairs from omega decay in the interaction $\pi^- + p \rightarrow \omega + n \rightarrow \mu^+ + \mu^- + n$ is proposed. Existence of a $1^-$ boson of narrow width, such as the omega meson, makes feasible the use of meson resonances in studying their electromagnetic interactions. Procedure and equipment to be used are treated briefly. (D.C.W.)

**11643** (UCRL-6930) PROTON SCATTERING BY $Ni^{64}$ AND $Zn^{64}$ AT 9.6 AND 11.7 Mev. J. Benveniste, A. C. Mitchell (California. Univ., Livermore. Lawrence Radiation Lab.), and C. B. Fulmer (Oak Ridge National Lab., Tenn.). May 28, 1962. Contract W-4705-eng-48. 28p.

Differential cross sections for elastic scattering of protons at 9.6 and 11.7 Mev from nickel-64 and zinc-64 are measured and compared. The observed shift in the positions of the maxima and minima of the differential cross sections is shown to be consistent with the presence of a symmetry energy term [C(N-Z)/A] in the real nuclear potential of the optical model. It is found that C ≈ 40 Mev, in reasonable agreement with the results of other observations. Comparison of the back angle data yields an estimate of about 16 mb for the compound elastic scattering cross section of $Zn^{64}$ at 9.60 Mev. The 11.7-Mev data show no contribution from compound elastic scattering. 40 references. (auth)

**11644** (UCRL-7001) HIGH ENERGY BREMSSTRAHLUNG FROM PROTON-NUCLEUS COLLISIONS (thesis). Walter C. Beckham (California. Univ., Livermore. Lawrence Radiation Lab.). Aug. 15, 1962. Contract W-7405-eng-48. 98p.

Theoretical calculations are described and numerical results given for the production of high energy bremsstrahlung from proton beam bombardment of nuclei. The results are compared with experiment. A best fitting momentum distribution is deduced for the nucleons in beryllium. It has a mean kinetic energy of 32 Mev. The model used assumes proton neutron interactions as a radiation source. Some calculations for a proton-nucleus interaction are given. These do not fit experimental data at all well. Born approximation was used. The parameters in a square well potential with exchange forces and a repulsive core are set up to agree with experimental neutron proton scattering, also calculated by Born approximation. The integration was done on computers. The exclusion principle was taken into account by excluding final states — or permitting them — in accordance with the fraction of phase space occupancy of the assumed momentum distribution. A notable feature is the strong dependence of radiation cross section on the assumed momentum distribution. (auth)

**11645** (UCRL-10099) ANGULAR-MOMENTUM EFFECTS ON NEUTRON EMISSION BY $Dy^{156}$, $Tb^{153}$, AND $Tb^{157}$ COMPOUND NUCLEI. Gabriel N. Simonoff and John M. Alexander (California. Univ., Berkeley. Lawrence Radiation Lab.). Feb. 26, 1962. Contract W-7405-eng-48. 42p.

The following reactions were studied: $Pr^{141}(C^{12},4n)Tb^{149g}$, $Nd^{146}(B^{11},8n)Tb^{149g}$; $Nd^{144}(C^{12},5n)Dy^{151}$; $Nd^{144}(C^{12},6n)Dy^{150}$; $Nd^{144}(C^{12},7n)Dy^{149}$; $Ce^{140}(O^{16},5n)Dy^{151}$; $Ce^{140}(O^{16},6n)Dy^{150}$; and $Ce^{140}(O^{16},7n)Dy^{149}$. The first two reactions, which directly produce the low-spin state of $Tb^{149}$, probably arise from compound nuclei of low angular momentum. The last six reactions have very different properties from the first two. These differences are attributed to differences in the angular momenta of the initial compound nuclei that give rise to these reactions. Excitation functions were measured or are available for all the reactions. Range distributions for the final nuclei are reported for the last six reactions. These range data give strong evidence for compound-nucleus formation. Angular distributions of the final nuclei for all the reactions are reported. From the angular distribution data the average energies of emitted photons and neutrons for each reaction are deduced. In the first two reactions the average total photon energy is less than 10 Mev. In the last six reactions the average total photon energy varies from ≈1 to more than 30 Mev. (auth)

**11646** (UCRL-10193) KINETIC ENERGY RELEASE IN 23 Mev DEUTERON FISSION OF $U^{238}$. John M. Alexander, M. F. Gazdik, and Saad Wasif (California. Univ., Berkeley. Lawrence Radiation Lab.). May 1961. Contract W-7405-eng-48. 22p.

Average recoil ranges were measured for five fission products formed by 23 Mev deuteron reactions with uranium-238. The ranges of products from near symmetric fission (cadmium-115 and silver-111) are longer than for neutron fission of uranium-235, while the ranges of asymmetric products (iodine-131, barium-140, and strontium-89) are shorter. The kinetic energy deficit for near symmetric fission is 15 to 20 Mev lower for this system than for thermal neutron fission of $U^{235}$. The magnitude of the kinetic energy deficit for uranium-236 fission is reexamined by comparing range data with recent time of flight measurements and neutron emission probabilities. This comparison leads to a kinetic energy deficit of approximately 23 Mev for uranium-236 fission. 23 references. (auth)

**11647** (UCRL-10202) ANOMALOUS QUADRUPOLE COUPLING IN EUROPIUM ETHYLSULFATE. D. A. Shirley and C. A. Lovejoy (California. Univ., Berkeley. Lawrence Radiation Lab. and California. Univ., Berkeley. Dept. of Chemistry). May 1962. Contract W-7405-eng-48. 23p.

Hyperfine structure, apparently of pure quadrupolar

form, was observed in the $Eu^{+2}$ ion in a neodymium ethylsulfate lattice. It has twice the predicted magnitude and opposite sign. Several crystal field effects were considered in attempting to explain the discrepancy, but none were successful. Pseudoquadrupole effects are shown not to be of primary importance because the coupling constant is negative. For $Eu^{152}$, $P^{152} = -6.7 \pm 0.5 \times 10^{-4}$ $cm^{-1}$ and for $Eu^{154}$, $P = -8.3 \pm 0.7 \times 10^{-4}$ $cm^{-1}$. The spin and parity assignments of 2- for the 1531-kev state in $Sm^{152}$ and the 1400 and 1723-kev states in $Gd^{154}$, as well as the electric dipole multipolarities of the radiations depopulating these states, were confirmed. The quadrupole moment of $Eu^{154}$ was found to be 3.24 ± 0.37 barns, assuming the interaction to be purely electric quadrupole. (auth)

**11648** (UCRL-10312) EXCITATION FUNCTION FOR THE $C^{12}(\pi^-,\pi^-n)C^{11}$ REACTION. Paul L. Reeder and Samuel S. Markowitz (California. Univ., Berkeley. Lawrence Radiation Lab. and California. Univ., Berkeley. Dept. of Chemistry). June 18, 1962. Contract W-7405-eng-48. 10p.

The assumption that nuclear reactions of the type $Z^A(\pi^-, \pi^-n)Z^{A-1}$ and $Z^A(\pi^-,\pi^-p)Z-1^{A-1}$ occur by single collisions on the surface of the nucleus is examined by determining the excitation function for the reaction $C^{12}(\pi^-,\pi^-n)C^{11}$ and comparing it with the function for free-particle scattering of negative pions on neutrons. Cross sections for the reaction are shown, and the reaction is deemed to proceed by direct collision of an incident particle and a neutron of carbon-12. (D.C.W.)

**11649** (UCRL-10481) SPONTANEOUS FISSION OF SOME HEAVY ISOTOPES (thesis). Reinhard Brandt (California. Univ., Berkeley. Lawrence Radiation Lab.). Sept. 26, 1962. Contract W-7405-eng-48. 76p.

A back-to-back semiconductor counter system was used to study the energy and mass distributions of the fragments in the spontaneous fission of $Fm^{254}$, $Es^{253}$, $Cf^{254}$, $Cf^{250}$, and $Cm^{248}$. The results are compared with the spontaneous-fission properties of $Cf^{252}$, which is used as a standard. All distributions (including those of the odd-mass isotope $Es^{253}$) are rather similar, but not identical with the standard. The total kinetic energy of the fragments increases with Z. The asymmetry of the mass distribution shows only small differences between the isotopes. The variances (widths) of all distributions increase with Z and seem to increase with A. A new Fm isotope with a spontaneous-fission half life of $(11^{+10}_{-6})$ days was observed. The mass is most likely 258 or 257. The spontaneous-fission half life of $(1.0^{+0.5}_{-0.3}) \cdot 10^4$y was observed for $Fm^{255}$. The $Cf^{254}$ spontaneous-fission half life was redetermined and is 60.5 ± 0.2 days. The alpha/fission ratio in the decay of $Cf^{250}$ was redetermined and is (1330 ± 45). The redetermined alpha-decay half life of $Fm^{255}$ is (19.9 ± 0.3) h. (auth)

**11650** (UCRL-10531) NUCLEAR REACTIONS INDUCED BY PIONS AND PROTONS (thesis). Paul L. Reeder (California. Univ., Berkeley. Lawrence Radiation Lab. and California. Univ., Berkeley. Dept. of Chemistry). Nov. 27, 1962. Contract W-7405-eng-48. 180p.

Effects due to elementary particle-like collisions within nuclear matter have been observed in several nuclear reactions caused by pions and protons. Simple nuclear reactions of the form $Z^A(a,an)Z^{A-1}$ and $Z^A(a,ap)(Z-1)^{A-1}$ have excitation functions that are sensitive to changes in the elementary-particle cross sections. The excitation function for the reaction $C^{12}(\pi^-, \pi^-n)C^{11}$ is measured from 53 to 1610 Mev by bombarding targets of plastic scintillator with pions. The intensity of the pion beam is monitored with a two-counter telescope and 40 Mc scaling system. The scintillator target is mounted on a phototube and becomes the detector for the carbon-11 positron activity. Corrections are made for muon contamination in the beam, coincidence losses in the monitor system, carbon-11 activity produced by stray background at the accelerator, carbon-11 activity produced by secondaries in the target, and the efficiency of the carbon-11 detection system. The $C^{12}(\pi^-, \pi^-n)C^{11}$ cross sections rise to a peak of about 70 mb at 190 Mev, that corresponds to the resonance in free-particle $\pi^-n$ scattering at 190 Mev. Calculations based on a "knock-on" collision mechanism and sharp-cutoff nuclear density reproduce the shape of the experimental excitation function, but the magnitudes of the calculated values are low by a factor of six. The calculation shows that the $C^{12}(\pi^-, \pi^-n)C^{11}$ reaction occurs in the nuclear surface region at all bombarding energies. The contributions to the $(\pi^-, \pi^-n)$ reaction predominate on the front surface of the nucleus in order to give the pion the maximum probability of escaping. The excitation functions for the reactions $Zn^{68}(p,2p)Cu^{67}$ and $Fe^{57}(p,2p)Mn^{56}$ are measured radiochemically from 400 Mev to 6.2 Bev. The slight increase in the (p,2p) cross sections measured from 400 to 720 Mev is related to the occurrence of a quasi-free-particle pp collision within the nucleus. Due to the proton momentum distribution, the increase is not as pronounced as the rise in free-particle pp total cross sections from 400 to 1000 Mev. From 2.2 to 6.2 Bev, the $Zn^{68}(p,2p)Cu^{67}$ and $Fe^{57}(p,2p)Mn^{56}$ cross sections are constant at 21 ± 2 mb and 50 ± 8 mb, respectively. The difference in magnitudes of the (p,2p) cross sections is ascribed to the availability of only two protons in zinc-68 and of six protons in iron-57 for this particular reaction. The free-particle effects are not seen in more complex reactions as evidenced by the constant cross sections from 0.72 to 6.2 Bev for the yields of manganese-51 and -52 from the reactions of protons with iron and for the yields of copper-61 and -64 from the reactions of protons with zinc. Cross sections are presented for a few products from pion-induced reactions requiring several nucleons to be emitted. The yields of manganese-56 and -52 and iron-52 from the bombardment of natural copper by negative pi meson, the yields of copper-67, -61, and -64 and manganese-52 and -56 from the negative pi meson bombardment of natural zinc, and the cross section for sodium-24 from negative pi meson + aluminum-27 are compared to the yields for similar reactions induced by protons. At the high energies considered here, interaction of negative pi meson with these targets is shown to give yields that are of the same order of magnitude as the yields from proton reactions. These results are interpreted as experimental evidence that pion processes are very important for energy transfer in high-energy nuclear reactions. 99 references. (auth)

**11651** DETERMINATION OF THE CROSS SECTION FOR THE REACTIONS $^{42}Ca(n,p)^{42}K$ AND $^{43}Ca(n,p)^{43}K$ AND METHODS FOR PRODUCTION OF CARRIER-FREE POTASSIUM ISOTOPES. Sevald Forberg (Royal Inst. of Tech., Stockholm). Acta Chem. Scand., 16: 2100-12(1962). (In English)

The cross sections for the (n,p) reactions of $Ca^{42}$ and $Ca^{43}$ were determined by reactor irradiation of $CaCO_3$, carrier-free separation of potassium, and comparison of the $K^{42}$ and $K^{43}$ activities with the activity of $Na^{24}$ obtained in a monitor of pure Al. The measured cross sections were 2.1 ± 0.4 and 1.5 ± 0.3 mb for $Ca^{42}$ and $Ca^{43}$, respectively, the theoretically predicted ones, 1.3 and 4.5 mb. The carrier-free separation method utilized included: dissolution of the irradiated calcium carbonate in hydrochloric acid; sorption of the calcium on Dowex A 1 chelating resin;

selective displacement of the potassium by means of ammonium chloride; substitution of the chloride with hydroxide, on an anion exchanger; and evaporation of the ammoniacal solution. This separation method should also be suitable for the production of carrier-free $K^{42}$ or $K^{43}$ activities from enriched $Ca^{42}$ and $Ca^{43}$, and make possible the recovery, with a high yield, of the expensive, enriched calcium isotopes. A fission neutron flux of $5 \times 10^{14}$ $s^{-1}$ $cm^{-2}$ should yield after one day's irradiation of 10 mg $Ca^{43}$, about one mC of $K^{43}$. Some advantages of carrier-free $K^{43}$ as compared with ordinary activated potassium are pointed out. (auth)

**11652** THE DECAY OF $Pm^{151}$. D. G. Burke, M. E. Law, and M. W. Johns (McMaster Univ., Hamilton, Ont.). Can. J. Phys., 41: 57-82(Jan. 1963).

The radiations from $Pm^{151}$ have been studied by external and internal conversion measurements and electron-electron, electron-beta, electron-gamma, and beta-gamma coincidence experiments. Thirty-six transitions have been identified. A decay scheme incorporating 30 of these has been established by energy and coincidence measurements with levels in $Sm^{151}$ at 0, 0.0048, 0.0658, 0.0697, 0.0915, 0.1048, 0.1677, 0.1684, 0.2090, 0.3239, 0.3449, 0.4445, 0.741, and 0.821 Mev. The half-life of the 0.0048-Mev level is $(19 \pm 10) \times 10^{-9}$ sec. The total decay energy is 1.195 ± 0.010 Mev. (auth)

**11653** NOTE ON THE REACTION $P^{31}(\gamma,n)P^{30}$. W. J. McDonald, E. Buchholz, and R. N. H. Haslam (Univ. of Saskatchewan, Saskatoon). Can. J. Phys., 41: 180-3 (Jan. 1963).

Magnetic moment considerations suggest resonance splitting in the $P^{31}(\gamma,n)P^{30}$ cross section. A reinvestigation of the cross section from threshold to 24 Mev is undertaken. The procedure is described, and a value of the half life is obtained as 2.497 ± 0.005 min. Values of $(3.37 \pm 0.03) \times 10^7$ reactions/g-atom-100 r and 12.45 ± 0.05 Mev, respectively, are reported for the absolute yield and the threshold of the reaction. The cross section plot reveals a plateau at 16 Mev and peaks at 18.2 and 19.5 Mev with a maximum cross section of 19 mb at 19.5 Mev and a half-width of the giant resonance of 7.5 Mev. These values agree well with others' results. (D.C.W.)

**11654** ELECTROMAGNETIC TRANSITIONS IN DEFORMED ODD-ODD NUCLEI. Alceu de Pinho (Laboratoire Joliot-Curie de Physique Nucleaire, Orsay, France and Centre de Recherches Physiques, Rio de Janeiro). Compt. Rend., 255: 2058-60(Oct. 22, 1962). (In French)

The reduced transition probabilities in deformed odd-odd nuclei are written in terms of those calculated for an A-odd nucleus. Some particular cases are discussed. (tr-auth)

**11655** STUDY OF THE RESONANT INTERACTION OF NEUTRONS WITH ENERGY NEAR 6.7 ev WITH URANIUM-238 NUCLEI IN URANIUM OXIDE AT LOW TEMPERATURE. André Michaudon, Hervé Derrien, Clément Le Pipec, and Pierre Ribon. Compt. Rend., 255: 2086-8 (Oct. 22, 1962). (In French)

The total resonant cross section at 6.68 ev of $U^{238}$ was measured by the time-of-flight method. The sample of $U_3O_8$ was carried successively to room temperature, 77 and 4°K. At room temperature, the resonant curve is in good agreement with the gas model without correction of effective temperature. At 77°K the resonance has a dissymmetrical form and is slightly displaced toward the low energies. At 4°K the dissymmetry is more pronounced and is compared with a theoretical formula. (tr-auth)

**11656** THE ANGULAR SCATTERING OF 6.9-Mev PROTONS BY CHROMIUM AND ZINC ISOTOPES. A. K. Val'ter, A. P. Klyucharev, V. A. Lutsik, B. F. Orlenko, M. V. Pasechnik, V. S. Prokopenko, and N. N. Pucherov (Inst. of Physics and Tech., Academy of Sciences, Ukrainian SSR). Doklady Akad. Nauk SSSR, 147: 1325-7(Dec. 21, 1962). (In Russian)

Thin, metallic foils enriched in $Cr^{50}$, $Cr^{52}$, $Cr^{53}$, $Cr^{54}$, $Zn^{64}$, $Zn^{68}$, or $Zn^{70}$ were irradiated with 6.8-Mev protons, and the angular distribution of elastically scattered protons was measured on a 50 channel, CsI(Tl) scintillation spectrometer over the angular region of 20 to 160° at each 5° with an angular error of ±0.3°. The ratio of the experimental cross section to the Rutherford cross section ($\sigma_{exp}/\sigma_{Ruth.}$) was found by normalizing the scattering measurements on the chromium isotopes at 40, 50, and 60° by a comparative method with respect to gold, for which the scattering is purely Coulombic for the energies used. A plot of $\sigma_{exp}/\sigma_{Ruth.}$ versus the scattering angle is presented. The scattering on $Cr^{52}$ at large angles was greater than on $Cr^{53}$ and $Cr^{54}$, and the scattering on $Cr^{50}$ was significantly more intensive than on $Cr^{52}$. The threshold for a (p,n) reaction on $Cr^{50}$ was 8.0 Mev, and on $Cr^{52}$ it was 5.63 Mev. The elastic scattering reaction on $Cr^{52}$ was found to compete with the (p,n) reaction. The threshold for the (p,n) reaction on $Zn^{64}$ was 8.0 Mev, but no sharp increase in the intensity of elastically scattered protons could be observed on this nucleide at large angles. A typical diffraction type of scattering was observed. Further research is required to explain this "anomalous" angular behavior of $Zn^{64}$. (TTT)

**11657** INTERNAL CONVERSION AND L FLUORESCENCE IN $Pa^{234}$ ($UX_2$). Anne-Marie Adamson, Maurice Duquesne, and Roger Foucher (Laboratoire Joliot-Curie de Physique Nucléaire, Orsay, France). J. Phys. Radium, 23: 580-1(Aug.-Sept. 1962). (In French)

The $\gamma$ conversion coefficients of the 63 and 29 kev levels of $Pa^{234}$ were measured by the $\gamma$-$\gamma$ coincidence method using NaI(Tl) crystals with great care being given to the geometry of the apparatus. It was concluded that the 29-kev radiation has a conversion coefficient >130. The 63-kev radiation is $E_1$. The mean L fluorescence coefficient is 0.52 ± 0.03. (J.S.R.)

**11658** GAMMA EMISSION FROM NUCLEI IN CRYSTALS. P. Chr. Hemmer. Kgl. Norske Videnskab. Selskabs. Forh., 34: 86-90(1961). (In English)

The Mössbauer effect is dependent on the high probability that emission or absorption of a photon by a nucleus in a crystal lattice is accompanied by the creation or annihilation of no phonons. A study is made of n-phonon transition probabilities and intensities, the mean photon energy, and the one-phonon spectrum. (T.F.H.)

**11659** GAMMA RAYS FROM THE CAPTURE OF FAST NEUTRONS IN Ta, W, Au, Hg, AND Pb. I. Bergqvist and N. Starfelt (Research Inst. of National Defence, Stockholm). Nucl. Phys., 39: 353-74(Dec. 1962). (In English)

Spectra of the $\gamma$ rays emitted when neutrons in the energy range 15 to 300 kev are captured in Ta, W, Au, Hg, and Pb were measured. The results were compared with experimental thermal nuetron capture $\gamma$ ray spectra and also with theoretically calculated spectra. Effects due to the capture of p wave neutrons were observed. Average partial widths for some high-energy $\gamma$ ray transitions were deduced from the experiment. (auth)

**11660** THE SINGLE PARTICLE NILSSON MODEL FOR ODD-MASS NUCLEI IN THE 1d-2s SHELL. Kumar H.

Bhatt (Univ. of Chicago). Nucl. Phys., 39: 375-93(Dec. 1962). (In English)

Nuclei in the 1d-2s shell are grouped according to their last odd nucleon number. Their properties are examined strictly within the framework of the extreme single particle Nilsson model. The effect of band mixing is included in a consistent way. Properties, such as energy spectra, magnetic moments and E2 and M1 transitions of odd-mass nuclei with Z or N = 9, 11 and 13 can be well described by the model. However, when Z or N = 15, it is not possible to fit these properties with a consistent variation of the parameters of the Nilsson potential. Nuclei with Z or N = 17 exhibit low-lying core excitations and therefore the extreme single particle model is not valid for them. (auth)

**11661** COLLECTIVE VIBRATIONS IN $Si^{30}$. V. K. Thankappan and S. P. Pandya (Physical Research Lab., Ahmedabad, India). Nucl. Phys., 39: 394-407(Dec. 1962). (In English)

The possibility of collective vibrations in nuclei in the region A ≈ 30 is discussed in terms of the systematics of the energy levels of even-even nuclei in the 2s-1d shell. As a test case, the energy levels and electromagnetic transition probabilities in $Si^{30}$ are calculated on the basis of the weak-coupling unified model. The inter-particle interactions between the last two neutrons as well as their interactions with the quantized harmonic vibrations of the $Si^{28}$ core (and $s_{1/2}$-$d_{3/2}$ configuration mixing) are taken into account. The results are found to be in fair agreement with the observed properties of $Si^{30}$, for a proper choice of the parameters. (auth)

**11662** TARGET POLARIZATION EFFECTS IN NUCLEAR REACTIONS. L. J. B. Goldfarb and D. A. Bromley (Yale Univ., New Haven, Conn.). Nucl. Phys., 39: 408-46 (Dec. 1962). (TID-16425) (In English)

Considerations of direct reactions, based on a distorted-wave formalism, show that the effects of polarized targets represented by the tensors, $\rho_{kx}(a)$, are simply correlated to the polarization of the residual nucleus, represented by $\rho_{kx}(b)$ when the target is unpolarized, provided that the transferred total angular momentum j is unique. Two related processes are considered: (1) A beam of unpolarized particles is incident on an unpolarized target and the angular dependence of the reaction-product yield associated with each tensor $\rho_{kx}$ (a) is measured. (2) With no polarization in the entrance channel, the angular dependence of the polarization of the residual nucleus is measured by identifying the coefficient of the $Y_x^k(\theta_\gamma, \phi_\gamma)$ in the triple angular correlation involving the incident beam, the reaction product and the de-excitation gamma radiation. It is found that these angular dependences are identical; furthermore the relative magnitudes of the partial cross sections in (1) and (2), for a given reaction-product angle, lead to a determination of j. Polarization tensors $\rho_{kx}$ (a) of rank $k > 2j_{max}$ should not affect the angular distributions. No detailed assumptions are made concerning the nature of the projectile or reaction product, nor the spin-dependence of either the interaction or the channel distortions, except that such distortions be independent of the spins of the target and residual nuclei. Upper bounds may also be given, provided that j is unique, to both the magnitudes of the asymmetry in the angular distributions associated with a given polarization tensor and the magnitudes of the polarization of the residual nucleus. For a given rank of polarization these upper bounds are functions merely of a, b, and j. In several cases, because of the accidental vanishing of Racah coefficients, selection rules may be given for polarization effects of a particular rank. The polarization correlation applies to a variety of direct processes, including knock-on phenomena. Experiments are proposed which help to disentangle direct-stripping amplitudes from those normally referred to as involving heavy-particle stripping where the polarization correlation is not simple unless additional assumptions are made concerning the spin dependence of optical-model potentials. It is demonstrated that provided j is unique, a series of measurements with polarized projectiles incident on polarized targets is sufficient to overdetermine the reaction amplitudes. Several processes are considered which involve spinless projectiles and reaction products and targets of integral spin. These need not be direct processes. So long as the target is appropriately polarized, observation of the reaction product, parallel or anti-parallel to the original motion, leads to a determination of the parity of the residual nucleus, and to the identification of non-zero spin states. (auth)

**11663** EMISSION OF ALPHA PARTICLES IN SPALLATION REACTIONS. Henri Gauvin, Marc Lefort, and Xavier Tarrago (Faculté des Sciences, Paris). Nucl. Phys., 39: 447-63(Dec. 1962). (In French)

In the course of studies on spallation reactions in thorium targets, it was found that the emission of alpha particles could explain high cross sections for Ac isotopes. A systematic study of both secondary reactions induced by α fragments, and Ac cross sections in the energy range 40-150 Mev has given the following results: 1) the α particles are emitted mainly in the forward direction; 2) the absolute cross sections of α fragments are 20 mb at 65 Mev, 35 mb at 85 Mev and 75 mb at 150 Mev; 3) these data were used in the calculation of cross sections for (p,αxn) reactions and good agreement was found with the experimental cross sections of Ac isotopes; 4) a mechanism is proposed of knock-out of α structures by prompt nucleons on the nucleus boundary. Spectra of prompt cascade nucleons and α particles were compared in two different cases (incident energies 82 and 150 Mev) and the results show a constant ratio of prompt nucleons over α particles for all intervals of energies. It is believed that these results show some evidence that a large proportion of nucleons on the surface of heavy nuclei belong to alpha particles (0.5 to 0.9). (auth)

**11664** THE VALUE OF $\int\alpha/i\int r$ IN BETA-DECAY THEORY. R. M. Spector (Centre d'Études Nucléaires, Saclay, France). Nucl. Phys., 39: 464-7(Dec. 1962). (In English)

Previous evaluations of the ratio B of the nuclear matrix elements $\int\alpha$ and $i\int r$ are discussed along with the implications of a conserved vector current theory of weak interactions. A new method of calculating B is given which uses an approach different from previous investigations. Results obtained are shown to agree with earlier work, and the experimental values of B are shown to be in agreement with the theoretical values for the nuclei $Bi^{210}$ and $Ce^{141}$. (auth)

**11665** PERTURBATION CORRECTIONS TO ENERGIES OF COLLECTIVE STATES IN DEFORMED EVEN NUCLEI. P. O. Lipas (Univ. of Helsinki, Finland). Nucl. Phys., 39: 468-78(Dec. 1962). (In English)

Corrections to gamma ray transition probabilities due to band mixing in deformed even nuclei are calculated. The concurrent energy shifts appearing as deviations from the rotational I(I + 1) dependence are calculated from the observed gamma ray branching ratios. Application of the resulting expressions to $Gd^{154}$ and $W^{182}$ shows that the experimental energy shifts far exceed the calculated values. The inclusion of an interaction between the β and γ vibrational bands in addition to the β-ground and γ-ground interactions does not change the results significantly in the

cases considered. Finally, a particular perturbation Hamiltonian, obtained from a hydrodynamic model with octupole vibrations included, is employed to calculate detailed expressions for energy corrections. (auth)

**11666** ELECTRON-GAMMA ANGULAR CORRELATION STUDIES WITH THE RADIATIONS FROM THE DE-EXCITATION OF $Pt^{192}$. D. K. Butt and B. C. Dutta (Univ. of London). Nucl. Phys., 39: 517-27(Dec. 1962). (In English)

Electron gamma angular correlation studies have been made between the 308, 296 and 316 kev radiations of the triple cascade of $Pt^{192}$. The measurements are in agreement with 2-2½% and ≈7% M1/E2 mixtures for the 296 and 308 kev transitions respectively and an E0/E2 K-electron mixture of 9 ± 4% for the 296 kev transition. The phase, in all cases, is negative. (auth)

**11667** THE EFFECTIVE $U^{238}$ RESONANCE CAPTURE INTEGRALS OF URANIUM METAL AND $UO_2$ RODS. J. Hardy, Jr., G. G. Smith, and D. Klein (Westinghouse Electric Corp., Pittsburgh). Nucl. Sci. Eng., 14: 358-65 (Dec. 1962). (WAPD-T-1448)

The effective $U^{238}$ resonance neutron capture integrals of uranium metal and $UO_2$ rods of a variety of diameters are measured by an activation technique. Small corrections are applied to compensate for departure of the flux spectrum from a 1/E shape. The results are compared with measurements and calculations. There is agreement for $UO_2$. For U metal agreement is not as good, but the difference is judged to be within the overall uncertainty. (auth)

**11668** SOME EXPERIMENTAL RESULTS PERTINENT TO EQUIVALENCE RELATIONS FOR EFFECTIVE RESONANCE INTEGRALS. J. Hardy, Jr., D. Klein, and G. G. Smith (Westinghouse Electric Corp., Pittsburgh). Nucl. Sci. Eng., 14: 366-70(Dec. 1962). (WAPD-T-1507)

An experimental test of several equivalence relations for effective resonance integrals is obtained from measurements of $U^{238}$ resonance escape probability for lattices of the TRX critical facility, and measurements of the $U^{238}$ resonance integrals of isolated rods of $UO_2$ and uranium metal. The TRX lattices are $H_2O$-moderated and composed of cylindrical, aluminum-clad fuel rods of slightly enriched uranium metal or $UO_2$. The measurements are in agreement with two forms of equivalence among lattice and isolated rod resonance integrals for a given fuel composition. The equivalence between resonance integrals for fuel rods of different compositions (U and $UO_2$) does not appear to be as good. (auth)

**11669** THE DIRECT INTERACTION IN THE THEORY OF NUCLEAR REACTIONS. Roger Balian and Vincent Gillet. Nucleus (Paris), No. 5, 371-80(Sept.-Oct. 1962). (In French)

The relation between experimental data and theoretical predictions in direct interactions is discussed. The theories developed to describe direct nuclear reactions are reviewed beginning with the Bohr hypothesis. The general characteristics of direct reactions are described, and the optical model and instantaneous inelastic reactions are considered. In conclusion direct interaction by ejection in the reaction $Be^9(n,2n)Be^8$ is shown to illustrate the theories considered. (J.S.R.)

**11670** PULSE ION CHAMBER IN THE APPLICATION TO THE ANALYSIS OF THE ENERGY OF PARTICLES ORIGINATED IN THE DISINTEGRATION OF THE COMPOUND NUCLEI OBTAINED BY BOMBARDMENT WITH THERMAL NEUTRONS. Zdzislaw Pawlowski. Nukleonika, 7: 183-92(1962). (In Polish)

An analysis was made of the energy of loaded particles emitted by the boron target, which is effected by the action of neutrons from a Po–Be source. The analysis was conducted at the pulse ion chamber filled with technically pure Ar. It was confirmed that particles emitted from the boron oxide target originate from the nuclear reaction $B^{10}(n,\alpha)Li^7$, $B^{10}(n,\alpha)Li^{7*}$. On the basis of the energy spectrum received, relative proportions between the effective cross-sections of the reactions is defined. Resolution and linearity of aparatus was examined by analysis of the spectra of known emitters of alpha radiation $U^{233}$, $U^{234}$, $U^{238}$, and $Pa^{231}$. (auth)

**11671** INELASTIC SCATTERING OF COLD NEUTRONS BY POLYCRYSTALLINE BERYLLIUM OXIDE IN THE TEMPERATURE RANGE FROM 100°K TO 1000°K. R. J. Begum, L. Madhav Rao, and N. Umakantha (Atomic Energy Establishment, Trombay, India). Phys. Chem. Solids, 23: 1747-51(Dec. 1962).

The total cross section of beryllium oxide for cold neutrons of mean wavelength 5.55 Å is measured in the temperature range from 100 to 1000°K. The results are satisfactorily interpreted in an expansion of the incoherent approximation. The values of the Debye temperature obtained from these measurements in the low and high temperature ranges are compared with those from specific-heat measurements. A method of choosing the effective mass and effective neutron cross section of a molecule in a diatomic lattice is suggested. (auth)

**11672** REACTIONS $(\gamma,n)$ IN $C^{12}$, $O^{16}$ AND $Ca^{40}$. J. Miller, G. Schuhl, G. Tamas, and C. Tzara (Centre d'Etudes Nucleaires, Saclay, France). Phys. Letters, 2: 76-8 (Aug. 15, 1962). (In French)

The $(\gamma,n)$ and $(\gamma,np)$ cross sections and integral cross sections at 15 to 26 Mev are studied for $C^{12}$, $O^{16}$, and $Ca^{40}$. Photoneutron production is found to be weak in comparison with photoproton production. It is also found that a strong T = 0 component in T = 1 excited states may exist, and that such a component favors photoproton production; that the level density in $N^{15}$ is much larger than that in $O^{15}$; and that dipole absorption has a large amplitude beyond the giant resonance. (T.F.H.)

**11673** PRODUCTION OF NEUTRAL PIONS IN THE INTERACTIONS OF 8.4 Gev/c $\pi^-$ MESONS WITH Xe NUCLEI. O. Czyżewski and J. Łoskiewicz (Inst. of Nuclear Research, Krakow). Phys. Letters, 2: 83-5(Aug. 15, 1962). (In English)

The production of photons in $\pi^-$ – Xe nucleus collisions was investigated at a primary momentum of 8.4 Bev/c. The photons were determined to be produced almost entirely in $\pi^0$ decay processes, and the angular distribution and energy spectrum of the parent neutral pions are shown. A comparison was made between the high energy part of laboratory spectra of secondary $\pi$-mesons produced in $\pi^-$–N collisions and $\pi^-$–C collisions and the $\pi^0$ mesons of the present experiment. The $\pi^0$-spectrum agrees very well with the $\pi^-$, but not with the $\pi^+$ spectra, from other experiments. Possible production processes that would account for the observed behavior are discussed. (H.D.R.)

**11674** THE UNIFORM BEHAVIOUR OF ELECTRIC QUADRUPOLE TRANSITION PROBABILITIES FROM FIRST $2^+$ STATES IN EVEN-EVEN NUCLEI. L. Grodzins (Massachusetts Inst. of Tech., Cambridge). Phys. Letters, 2: 88-91(Aug. 15, 1962). (In English)

The gamma transition probabilities from the first $2^+$

states of even-even nuclei, $T_\gamma$ ($2l \rightarrow 0$), are shown to exhibit a uniform behavior from A = 12 to 240. These transition probabilities are approximately proportional to $E^4$, where E is the energy of the transition. No discontinuity in this relation is evident as the boundaries between deformed and spherical nuclei are crossed. Therefore, it is not possible on the basis of $T_\gamma(2l \rightarrow 0)$ alone to distinguish a collective vibrational from a collective rotational first $2^+$ state. (H.D.R.)

**11675** INDICATIONS FOR THE EXISTENCE OF ERICSON FLUCTUATIONS IN THE REACTION $Al^{27}(d,\alpha)Mg^{25}$. Y. Cassagnou, C. Levi, M. Mermaz, and L. Papineau (Centre d'Etudes Nucléaires, Saclay, France). Phys. Letters, 2: 93-5(Aug. 15, 1962). (In French)

The differential cross sections for the reaction $Al^{27}(d,\alpha)Mg^{25}$ are measured at deuteron energies of 2 to 5 Mev and for nine groups of alpha particles (namely, those leading to the ground, first-excited, etc., states of $Mg^{25}$). The distributions for single levels are fitted to Legendre polynomials, and are found to be asymmetric about 90°. These distributions vary widely from level to level. Sums of these distributions over the energy levels involved, however, yield distributions that are symmetric around 90°. The results are found to be in agreement with fluctuation predictions from the statistical nuclear theory. (T.F.H.)

**11676** OPTICAL MODEL PARAMETERS FOR THE INTERACTION OF INTERMEDIATE ENERGY DEUTERONS WITH NUCLEI. M. A. Melkanoff (Centre d'Etudes Nucléaires, Saclay, France), T. Sawada, and N. Cindro. Phys. Letters, 2: 98-9(Aug. 15, 1962). (In English)

The optical model has been used to analyze the elastic scattering of deuterons in the energy range 3 to 30 Mev with particular emphasis on C, Mg, Ni, Rh, and Au. The analysis was carried out with a volume absorption potential including a real spin orbit coupling of the Thomas form and characterized by the usual five parameters V, W, $V_{so}$, A, and $R_\sigma$. Although the calculations yield the differential scattering cross sections, the reaction cross sections, and the four polarizations, comparison with experiment is limited to the former due to lack of other data. The values of the parameters obtained as a result of the analysis are tabulated. (H.D.R.)

**11677** QUASI-FREE PROTON-PROTON SCATTERING FROM Ca AT 180 Mev. G. Tibell, O. Sundberg, and U. Miklavzic (Univ. of Uppsala). Phys. Letters, 2: 100-1(Aug. 15, 1962). (In English)

A 185-Mev proton beam incident on a natural calcium target was used to separate the peaks corresponding to the three least bound proton groups in $Ca^{40}$. Summed-energy spectra were recorded for scattering angles from 35 to 60° in the 0 to 20 Mev binding energy region. The binding energies are derived from the spectra, and angular correlation distributions for the three groups are shown. (H.D.R.)

**11678** THE ALPHA SPECTRUM FROM $(\gamma,\alpha)$ ON $V^{51}$. M. Kregar and B. Povh (Nuclear Institute "J. Stefan," Ljubljana, Yugoslavia). Phys. Letters, 2: 103-4(Aug. 15, 1962). (In English)

The $\alpha$-spectra from $V^{51}(\gamma,\alpha)Sc^{47}$ are shown for 21 and 30 Mev end point betatron energies. Assuming an isotropic angular distribution for emitted alphas, total integrated cross sections of $2.4(1 \pm 0.3)$ and $6(1 \pm 0.3)$ mb Mev were obtained for 21 and 30 Mev energies, respectively. The magnitude of the cross sections as well as the alpha spectra for the reaction agree with the statistical model. (H.D.R.)

**11679** MEASUREMENTS OF MASS OF SINGLE CHARGED PARTICLES EMITTED BY ABSORPTION OF MESONS IN EMULSION NUCLEI. N. R. Rabin, A. O. Weissenberg, and E. D. Kolganova (Inst. of Theoretical and Experimental Physics, Moscow). Phys. Letters, 2: 110-12 (Aug. 15, 1962). (In English)

The mass of single charged particles emitted from stars produced by absorption of slow $\pi^-$ mesons stopped in emulsion were measured in the range 20 to 100 Mev. Capture phenomena on light (C, N, and O) and heavy (Ag and Br) nuclei were differentiated on the basis of the standard criteria of Coulomb barrier and Auger electrons. The basic results were obtained by measuring the multiple Coulomb scattering by the constant sagitta method, and the measurements were repeated by counting the number of $\delta$ electrons versus residual range and by measuring ionization versus residual range. (H.D.R.)

**11680** THE 661 kev RESONANCE OF THE $Mg^{26}(p,\gamma)$ REACTION. T. R. Ophel and B. T. Lawergren (Australian National Univ., Canberra). Phys. Letters, 2: 167-8(Sept. 15, 1962). (In English)

The gamma spectrum at the 661-kev resonance of the $Mg^{26}(p,\gamma)$ reaction was measured in an attempt to clarify the assignment of spin to the 2.21-Mev level of $Al^{27}$. The constituent gamma rays of the spectrum obtained by line shape analysis are summarized. The absence of a transition via the 2.21-Mev level at this resonance indicates that all gamma measurements are consistent with an assignment of spin $J = {}^7/_2{}^+$. (H.D.R.)

**11681** ON RESONANCE PEAKS IN THE (p,n) REACTIONS. K. Ikeda, S. Fujii, and F. I. Fujita (Nihon Univ., Tokyo). Phys. Letters, 2: 169-71(Sept 15, 1962). (In English)

It has been previously shown that the giant resonance peak in the nuclear photoeffect can be understood as a superposition of the like particle-hole pairs, $(p\bar{p})$ and $(n\bar{n})$, in terms of the shell model. This formalism may be easily extended to an unfamiliar kind of collective state made by superimposing the unlike particle-hole pairs $(p\bar{n})$. Discussed here is the possibility of observing such a collective state experimentally in the $(p,\bar{n})$ reaction of a heavier nucleus. The model formulated is used to perform example calculations for lead. (H.D.R.)

**11682** A NOTE ON THE PARTICLE-HOLE DESCRIPTION OF INELASTIC ALPHA PARTICLE EXCITATION. E. A. Sanderson and N. S. Wall (Univ. of Copenhagen). Phys. Letters, 2: 173-5(Sept. 15, 1962). (In English)

A simplified calculation is presented to estimate the ratio of the inelastic scattering intensity of alpha particles to the several excited $3^-$ states compared to that leading to the first excited state of $Ca^{40}$. The analysis is essentially the same as the calculation of the electric octupole radiation of these states with the two differences. The alpha-nucleon interaction is taken to be scalar in isospin space so that only the T = 0 ground state components of the various excited states are excited, and the radial operator whose transition matrix element is calculated is not $r^3$ but some other function of r that emphasizes the tail of the nucleon wave functions more strongly than $r^3$. Results of the analysis are given for states previously predicted by Gillet and Sanderson for the $3^-$ and the $5^-$ states. (H.D.R.)

**11683** EVIDENCE FOR A 1.7 Mev LEVEL IN $B^9$. G. D. Symons and P. V. Treacy (Australian National Univ., Canberra). Phys. Letters, 2: 175-7(Sept. 15, 1962). (In English)

An 11.87 Mev proton beam was used to bombard a target of natural carbon, and the spectrum of charged particles produced was analyzed. A broad group was found that is attributable to $\alpha$ particles from the $C^{12}(p,\alpha)B^9$ reaction. Analysis of this spectrum indicates the existence of an ex-

cited state of $B^9$ at 1.7 ± 0.2 Mev and reduced width 1.0 Mev. (H.D.R.)

**11684** ANGULAR CORRELATION SYMMETRIES. E. Sheldon (Eidgenössische Technische Hochschule, Zurich) Phys. Letters, 2: 178-82(Sept. 15, 1962). (In English)

A survey is presented of the correlation symmetries expected theoretically from compound nucleus and direct interaction mechanisms in the p'-γ inelastic scattering process. Theoretical and experimental research values from the reaction $Ni^{58}(p,p'\gamma)$ at $E_p$ = 5.73 Mev are used as illustrative examples of correlation symmetries. (H.D.R.)

**11685** HIGH PHONON STATES OF QUADRUPOLE VIBRATION IN SPHERICAL NUCLEI. Yasukazu Yoshizawa (Inst. for Theoretical Physics, Copenhagen). Phys. Letters, 2: 261-3(Oct. 15, 1962). (In English)

Recently many strong low energy gamma rays (< 1 Mev) have been observed between excited states of $Pd^{106}$, $Cd^{108}$, $Cd^{110}$, and $Cd^{114}$. In comparison with the branching ratios obtained from the Weirskopf estimate, these transitions are much stronger than high energy transitions (>1 Mev). The spherical vibration model suggests that one phonon transition is enhanced, while two or higher phonon transitions are hindered. To explain this fact for transitions from second $2^+$ states, several nuclear models have been proposed. An attempt is made to assign higher excited states in terms of the spherical vibration model. (W.D.M.)

**11686** THE 2.21 Mev LEVEL OF $Al^{27}$. B. T. Lawergren and T. R. Ophel (Australian National Univ., Canberra). Phys. Letters, 2: 265(Oct. 15, 1962). (In English)

Angular distribution and γ-γ correlation measurements, obtained at a narrow (≤2 kev) isolated resonance of the $Mg^{26}(p,\gamma)$ reaction at 2.81 Mev, have enabled a unique spin assignment to be determined. The resonance, corresponding to a level in $Al^{27}$ at 10.98 Mev, decays mainly to the ground state and the 1.01 and 2.21 Mev levels of $Al^{27}$. (W.D.M.)

**11687** PION CAPTURE AS A TOOL FOR SHELL MODEL STUDIES. T. Ericson (CERN, Geneva). Phys. Letters, 2: 278-80(Oct. 15, 1962). (In English)

The success of quasi-elastic nucleon scattering in complex nuclei as a means of studying one-hole excitations in the shell model raises the question of two-hole excitations. Their existence is a logical consequence of a strict shell model; the deviations or simularities of energies and wave functions to the ones obtained from the one-hole excitations should provide experimental information on the range of validity and the corrections to the shell-model picture. It is pointed out that the capture of stopped $\pi^-$ mesons should be useful for the study of two-hole excitations. (W.D.M.)

**11688** ELASTIC SCATTERING ANGULAR DISTRIBUTIONS AND TOTAL REACTION CROSS SECTIONS FOR THE INTERACTION OF 12.8 Mev DEUTERONS WITH $Ni^{58}$ AND $Ni^{60}$ NUCLEI. A. Budzanowski and K. Grotowski (Inst. of Nuclear Physics, Krakow). Phys. Letters, 2: 280-1(Oct. 15, 1962). (In English)

Recently optical model analysis has been applied to fit the experimental angular distribution data of the elastic scattering of deuterons by nuclei. In view of a considerable dependence of $\sigma_R$ on the shape of the real and imaginary part of the potential at the nuclear surface, it was thought worthwhile to measure both $\sigma_{el}(\theta)$ and $\sigma_R$ for 12.8 Mev deuterons on targets of separated $Ni^{58}$ and $Ni^{60}$ isotopes. (W.D.M.)

**11689** THE HALF-LIFE OF THE 57 kev FIRST EXCITED STATE IN $Pr^{143}$. M. S. El-Nesr and E. Bashandy (Univ. of Uppsala). Phys. Letters, 2: 287-8(Oct. 15, 1962). (In English)

A half life $(2.9 \pm 0.2) \times 10^{-9}$ sec has been found for the 57-kev first excited state in $Pr^{143}$. $Ce^{143}$ activity was produced by neutron irradiation of spectroscopically pure cerium metal. The measurements were performed in an electron-electron coincidence spectrometer by means of the delayed coincidence technique. A fast-slow coincidence unit with an effective resolving time $2\tau$ = 3ns was used. (W.D.M.)

**11690** ISOMERIC STATE IN $Yb^{176}$. J. Kantele (Univ. of Arkansas, Fayetteville). Phys. Letters, 2: 293-4 (Oct. 15, 1962). (In English)

In a search for further cases of K-isomerism, a new 11.7 ± 0.5 sec gamma activity was found in irradiations of Yb metal with 14-15 Mev neutrons. On the basis of subsequent experiments, this activity was firmly assigned to an isomeric state in $Yb^{176}$. The cross section for formation of this isomer (by an $Yb^{176}$ + n reaction) was measured to be 5 ± 2 mb at 14-15 Mev. (W.D.M.)

**11691** THE INTERPRETATION OF ISOMERIC SHIFT IN $Fe^{57}$. J. Frahm and A. Gustavs (Kernphysikalisches Institut der Deutschen Akademie der Wissenschaften, Berlin). Phys. Letters, 2: 296-7(Oct. 15, 1962). (In German)

The dependence of isomeric shift in $Fe^{57}$ on change in the effective charge distribution is discussed. Reasons for changes in the effective charge radius are listed. A formula for calculation of the dependence of the isomeric shift on the electric quadrupole moment is presented. (M.C.G.)

**11692** HYPERFINE STRUCTURE OF THE METASTABLE $(4p)^5(5s)\ ^3P_2$ STATE OF $_{36}Kr^{83}$. W. L. Faust and L. Y. Chow Chiu (Columbia Univ., New York). Phys. Rev., 129: 1214-20(Feb. 1, 1963).

The hyperfine structure (hfs) of the metastable $(4p)^5(5s)$ $^3P_2$ state of $Kr^{83}$ (I = 9/2) has been measured by the atomic beam magnetic resonance method. The zero magnetic field intervals are: $f(11/2 \longleftrightarrow 13/2)$ = 1830.7236(5) Mc/sec, $f(9/2 \longleftrightarrow 11/2)$ = 1341.8217(2) Mc/sec, $f(7/2 \longleftrightarrow 9/2)$ = 956.5583(2) Mc/sec, and $f(5/2 \longleftrightarrow 7/2)$ = 656.0844(30) Mc/sec. The four frequencies (after correction for second-order hyperfine interaction) are expected to be linearly related to only three interaction constants: A', B', and C' (respectively dipole, quadrupole, and octupole). The fit is satisfactory if, and only if, second-order hyperfine interaction is taken into account. The quadrupole and octupole moments of $Kr^{83}$ are Ω = –0.18(6) nm b (nuclear magneton barn) and Q = +0.270(13)b. These values include no polarization corrections or corrections for any effects of configuration mixing. (auth)

**11693** NEUTRON-PRODUCING REACTIONS BY DEUTERON BOMBARDMENT OF $B^{11}$. H. J. Kim and E. F. Shrader (Case Inst. of Tech., Cleveland). Phys. Rev., 129: 1275-81(Feb. 1, 1963).

The neutrons produced by deuteron bombardment of a thin, enriched $B^{11}$ target have been studied for nine different deuteron energies ranging from 1.60 to 2.70 Mev. The absolute differential cross sections for the production of neutrons feeding well-established states in $C^{12}$ were determined. In addition to the monoenergetic neutron groups feeding the states of $C^{12}$, previously unreported continuum neutrons due to many-body breakup of deuteron plus $B^{11}$ system were observed and analyzed. The breakup mechanism is inferred to be a direct reaction process rather than the compound nucleus process. The angular distributions of neutrons leaving $C^{12}$ in 15.11 Mev ($1^+$), Q = –1.37 Mev and 12.73 Mev ($1^+$), Q = +1.00 Mev states were studied in detail. The effect of compound resonance at $E_d$ = 2.18 Mev

on the angular distributions of the above neutron groups was studied. The investigations were performed employing time-of-flight technique utilizing pre-acceleration pulsed, post-acceleration bunched deuteron beam from a 3-Mev Van de Graaff accelerator. (auth)

**11694** PROPERTIES OF $F^{20}$. S. S. Glickstein and R. G. Winter (Pennsylvania State Univ., University Park). Phys. Rev., 129: 1281-3(Feb. 1, 1963).

The half-life of $F^{20}$ is 11.36 ± 0.07 sec. The thermal $F^{19}(n,\gamma)F^{20}$ cross section is 10.09 ± 0.70 mb. Limits on the improbable decay modes of $F^{20}$ were obtained. (auth)

**11695** QUASI-DEUTERON MODEL AND THE INTERNAL MOMENTUM DISTRIBUTION OF NUCLEONS IN $C^{12}$. Young S. Kim (Ohio State Univ., Columbus). Phys. Rev., 129: 1293-7(Feb. 1, 1963).

The quasi-deuteron model was assumed in computing the internal momentum distribution of nucleons in $C^{12}$ using the monoergic photodata of Cence and Moyer and the bremsstrahlung photodata of the Purdue group. The computed quasi-deuteron momentum distribution has the form $A \exp(-p^2/4ME_1)/(4\pi ME_1)^{1.5} + Bp^2 \exp(-p^2/4ME_2)/1.5\pi^{1.5}(4ME_2)^{2.5}$, where $E_1$ is 1.5 Mev and $E_2$ is 5 Mev. The ratio B/A is approximately 2. These two components resemble the (1s) and (1p) wave functions of the shell model. The (1s) component is associated with a binding energy 40 Mev while the (1p) component is associated with a binding energy 10 Mev. The internal momentum distribution of nucleons in $C^{12}$ was calculated from this quasi-deuteron momentum distribution assuming that the nucleons exist in proton-neutron pairs in the nucleus. (auth)

**11696** CROSS SECTIONS FOR INFORMATION OF THE ISOMERIC PAIR $In^{117}$ AND $In^{117m}$ IN THE $Sn^{120}(p,\alpha)$ REACTION. John L. Need and Bruno Linder (Oak Ridge National Lab., Tenn.). Phys. Rev., 129: 1298-1301(Feb. 1, 1963).

The excitation functions and yield ratio ($\sigma_g/\sigma_m$) for the isomeric pair $In^{117}$ and $In^{117m}$ produced from $Sn^{120}$ by the $(p,\alpha)$ reaction were measured for energies from threshold to 22 Mev. The yield ratio vs energy is large at low energies, drops to a minimum at 13 Mev, and then rises linearly to 22 Mev. The measured half-lives of the excited and ground state of $In^{117}$ were found to be 117.5 ± 1.0 and 44.6 ± 0.6 min, respectively. (auth)

**11697** ANALYSIS OF THE ENERGY DEPENDENCE OF THE ISOMER RATIO IN THE $Sn^{120}(p,\alpha)In^{117,117m}$ REACTION. John L. Need (National Aeronautics and Space Administration, Cleveland). Phys. Rev., 129: 1302-7(Feb. 1, 1963).

The method of Huizenga and Vandenbosch for calculating isomer ratios has been extended to reactions that constitute a small fraction of the total cross section. In particular, the method determines the effective distribution in J for emission of particles a brought about by competition between the emission of neutrons and particles a. The method is then applied to the reaction $Sn^{120}(p,\alpha)In^{117,117m}$, and values of $\sigma$, the parameter that characterizes the spin distribution, are extracted by comparison with experiment. The values of $\sigma$ obtained for proton bombarding energies of 12 and 18 Mev are 2.7 and 4.2, respectively, and do not depend strongly upon the value of $\sigma$ chosen for the neutron evaporation, but do depend strongly upon the fractional amount of direct interaction assumed. Similar values for $\sigma$ are obtained when competition is not considered. The energy dependence of $\sigma$ is discussed in the light of present theory. (auth)

**11698** STRUCTURE OF LOW-LYING $2^+$ STATES IN EVEN-EVEN NUCLEI AND BETA-GAMMA ANGULAR CORRELATIONS. Z. Matumoto (Atomic Energy Research Inst., Tokyo), M. Yamada, I-T. Wang, and M. Morita. Phys. Rev., 129: 1308-15(Feb. 1, 1963).

The ground states with spin $2^-$ of the odd-odd nuclei decay into those of the even-even nuclei through several channels, $2^- \xrightarrow{\beta_1} 0^+$, $2^- \xrightarrow{\beta_1} 2^+ \xrightarrow{\gamma} 0^+$, etc. In the $2^- \xrightarrow{\beta_1} 2^+$ transition, all first forbidden matrix elements other than $B_{ij}$ are reduced in magnitude from their normal values, if the j selection rule of the j-j coupling shell model or the K selection rule of the rotational excitation in the collective model is realized in the main configurations of states $2^-$ and $2^+$. In such a case, the present theory distinguishes whether the $\beta_2$ decay obeys the j selection rule or the K selection rule. Furthermore, if the j selection rule holds, the theory gives the configuration of the low-lying $2^+$ state. This is done by combining the data on $\beta_2 - \gamma$ directional correlations and branching ratio of $\beta_1$ and $\beta_2$, with the calculated value for $(\int B_{ij})_1/(\int B_{ij})_2$ which is nuclear-model dependent. The first excited $2^+$ states in $Se^{76}$, $Sr^{86}$, $Te^{122}$, and $Xe^{126}$ are studied in comparison with available data on beta decays of $As^{76}$, $Rb^{86}$, $Sb^{122}$, and $I^{126}$. (auth)

**11699** PARTICLE MODEL OF SCATTERING FROM COLLECTIVE STATES OF NUCLEI. Leonard S. Kisslinger (Western Reserve Univ., Cleveland and Univ. of California, Berkeley). Phys. Rev., 129: 1316-29(Feb. 1, 1963).

The differential cross sections for the excitation of the vibrational levels of nuclei are derived using the direct interaction between the projectile and the shell-model particles via a two-body force. The nuclear collective states are approximate solutions to the Hamiltonian consisting of a pairing plus a quadrupole interaction in a quasi-particle representation. The results obtained by this method are compared to those which follow from an interaction using collective coordinates for states of one and two phonons. Numerical results are given for the plane-wave first Born approximation scattering of alpha particles with a delta-function interaction between the projectiles and the nuclear particle and for the plane-wave Born approximation scattering of electrons, assuming a Coulomb interaction. (auth)

**11700** NUCLEAR g FACTOR OF THE FIRST EXCITED STATE IN $V^{51}$. Ingrid Y. Krause (Franklin Inst., Swarthmore, Penn.). Phys. Rev., 129: 1330-3(Feb. 1, 1963).

The angular distribution of the resonance radiation from the 320-kev state in $V^{51}$ has been measured using gaseous $Cr^{51}Cl_2O_2$ as the source of resonant gamma rays. The distribution can be described by $W(\theta) = 1 + (0.44 \pm 0.03)P_2(\cos\theta)$, corresponding to a mixing amplitude $\delta = +0.43 \pm 0.03$. From the precession of the angular distribution pattern in a magnetic field perpendicular to the plane of scattering, a value $g = 1.69 \pm 0.29$ was deduced for the g factor of the excited state, using $\tau = (2.5 \pm 0.2) \times 10^{-10}$ sec for the mean life. (auth)

**11701** E2/M1 MIXING RATIO OF THE 123-kev TRANSITION IN $Fe^{57}$ DETERMINED FROM A MÖSSBAUER COINCIDENCE EXPERIMENT. H. de Waard (Univ. of Groningen, Netherlands) and F. van der Woude. Phys. Rev., 129: 1342-4(Feb. 1, 1963).

For gamma cascades (2) $\xrightarrow{\gamma_2}$ (1) $\xrightarrow{\gamma_1}$ (0) in nuclei where the separate magnetic components of the ground-state transition (1) → (0) can be observed by the Mössbauer effect because there is a strong internal magnetic field, information about the multipole character of $\gamma_2$ and $\gamma_1$ can be obtained by measuring the relative intensities of the magnetic components of $\gamma_1$ in coincidence with $\gamma_2$ for specified emission angles of $\gamma_1$ and $\gamma_2$ with respect to an external polarizing field. In particular, the mixing ratio of $\gamma_2$ can be determined if the spins of the levels and the multiple character of $\gamma_1$ are known. One advantage of this method over normal $\gamma$-$\gamma$ directional correlation experiments is that the populations

of the sublevels of state (1) are independent of the precession of the nuclear spin axis around the field direction. This makes the method especially suitable for cases where the lifetime of state (1) is so long that the directional correlation is appreciably affected by the precession. Another advantage of the method is that there is no averaging effect of the summation over the sublevels. The method has been used to determine the E2/M1 mixing ratio of the 123-kev transition in the $(^5/_2\text{-}) \xrightarrow{123\ \text{kev}} (^3/_2\text{-}) \xrightarrow{14.4\ \text{kev}} (^1/_2\text{-})$ cascade in $Fe^{57}$. Both gamma rays were observed under angles of 90° with respect to the field magnetizing the Armco foil in which the $Co^{57}$ activity was diffused. Designating the intensities of the components of $\gamma_1$ observed in coincidence with $\gamma_2$ by $I_1^c \cdots I_6^c$ from low to high energy) the following ratios were measured: $I_4^c/I_2^c = 0.91 \pm 0.035$ and $I_6^c/I_5^c = 0.89 \pm 0.035$. Taking into account incomplete magnetization of the source and finite solid angles of the counters, an E2/M1 mixing ratio $\delta = -0.15 \pm 0.035$ is derived from these ratios. (auth)

**11702** NUCLEAR MOMENTS AND HYPERFINE STRUCTURE OF 13-YEAR $Eu^{152}$. Seymour S. Alpert (Univ of California, Berkeley). Phys. Rev., 129: 1344-9 (Feb. 1, 1963).

The magnetic dipole interaction constant a and the electric quadrupole interaction constant b for $Eu^{152}$ (13 yr) were measured by the method of atomic beams. These values are $a = \pm 9.345 \pm 0.006$ Mc/sec and $b = \mp 1.930 \pm 0.165$ Mc/sec. By comparison with the known moment of $Eu^{151}$, the nuclear dipole moment of $Eu^{152}$ was found to be $\mu = \pm 1.912 \pm 0.004$ nm. The sign of this moment cannot be inferred from the experimental results. The zero-field hyperfine between levels of different total angular momentum were directly measured. (auth)

**11703** EFFECT OF ANGULAR LOCALIZATION ON DIRECT NUCLEAR REACTIONS. Paul A. Benioff (Argonne National Lab., Ill.). Phys. Rev., 129: 1355-61 (Feb. 1, 1963). (TID-17095)

Some interesting effects of the angular localization of reaction sites caused by the damping of the incident and exit particle waves by the nuclear optical potential are described. Using the reactions $Li^7(p,2p)He^6$ and $Be^9(p,2p)Li^8$, as examples, it is shown that, due to the angular localization, the total reaction cross section is different for aligned than for unaligned target nuclei. For the $Li^7$ target in j-j or L-S coupling the fractional change, f, in the cross section for an incident energy of 6 Bev was given by $f = 0.165(2x - 1)$, where x is the fractional population of $Li^7$ in the $M = |^3/_2|$ substates. At 140 Mev the value of the constant in the above expression was slightly but not significantly smaller. For the reaction $Be^9(p,2p)Li^8$ the fractional change in the cross section is one half of and of the opposite sign of the $Li^7$ value for the same amount of target alignment. Another result of angular localization of reaction sites in the nucleus is that $J \neq 0$ product nuclear states will be oriented with respect to the incident beam. Using (p,pn) and (p,2p) reactions on $O^{16}$ and $Ni^{58}$ as examples, the amount of product nuclear state alignment was computed for the $1p_{\frac{1}{2}}$ and $1f_{\frac{1}{2}}$ excited hole states of $O^{15}$, $N^{15}$, and $Ni^{57}$. The population ratios obtained for the substates in $O^{15}$ or $N^{15}$ were $|^3/_2|$: $|^1/_2| = 0.58 : 0.42$ and for $Ni^{57}$, $|^7/_2| : |^5/_2| : |^3/_2| : |^1/_2| = 0.34 : 0.25 : 0.21 : 0.20$. The angular anisotropies, $[W(\pi/2) - W(0)]/W(\pi/2)]$, expected from gamma decay of these states were computed to be −0.125 assuming an M1 transition for the $O^{15}$ or $N^{15}$ $^3/_2$-states and 0.162 assuming an E2 transition for the $Ni^{57}$ $^7/_2$-state. (auth)

**11704** HIGH-ENERGY PHOTOPROTONS FROM LIGHT NUCLEI. Y. S. Kim, F. F. Liu, F. J. Loeffler, and T. R. Palfrey, Jr. (Purdue Univ., Lafayette, Ind.). Phys. Rev., 129: 1362-7(Feb. 1, 1963).

Photoprotons produced in Li, Be, B, and C targets by bremsstrahlung with a peak energy of 335 Mev were observed at eight angles between 20° and 96° in the laboratory. Protons with energies between 140 Mev and 192 Mev were detected by means of a scintillation counter telescope which simultaneously observed three adjacent energy bins. Corrections to the data for nuclear absorption in the target, multiple scattering in the target and counter telescope, pion contamination, and other small effects have been made. The results are compared with Levinger's quasi-deuteron model. The width of the momentum distribution for the quasi-deuteron inside the nucleus and the differential cross section for the photodisintegration of the quasi-deuteron were used alternatively as adjustable quantities in fitting the data. If experimental data for the free deuteron photoeffect are used, it is found that a fairly wide momentum distribution with tails falling more slowly than those of a Gaussian is required for agreement with this measurement. (auth)

**11705** NUCLEAR ALIGNMENT OF $Ce^{137m}$, $Ce^{137}$, $Ce^{139}$, $Ce^{141}$, AND $Ce^{143}$. J. N. Haag, D. A. Shirley, and David H. Templeton (Univ. of California, Berkeley). Phys. Rev., 129: 1601-13(Feb. 15, 1963). (UCRL-10242)

Nuclei of $Ce^{137m}$, $Ce^{137}$, $Ce^{139}$, $Ce^{141}$, and $Ce^{143}$ were aligned at low temperatures by the magnetic hyperfine-structure method. The angular distributions and the plane polarization of the emitted gamma radiation were measured as functions of temperature. For the spin sequence $(Ce^{137m})11/2(M4, E5, 255\ kev)^3/_2(Ce^{137})$, the mixing ratio, $|\delta(E5/M4)|$, is less than 0.7. For the sequence $(Ce^{137})^3/_2(i_\beta = 0,1)^3/_2(M1, E2, 445\ kev)^5/_2$, the magnetic moment of $Ce^{137}$ is $|\mu_N| = 0.90 \pm 0.15$ nm and $-2.6 < \delta(E2/M1) < -0.17$. The spin of the 455-kev level of $La^{137}$ is shown to be $^3/_2$. For the sequence $(Ce^{139})^3/_2(i_\beta = 1)^5/_2(M1, E2, 166\ kev)^7/_2(La^{139})$, the magnetic moment of $Ce^{139}$ is $|\mu_N| = 0.95 \pm 0.20$ nm and $\delta(E2/M) = +0.034 \pm 0.034$. The 166-kev level of $La^{139}$ has spin $^5/_2$. For the sequence $(Ce^{141})^7/_2(i_\beta = 0)^7/_2(M1, E2, 142\ kev)^5/_2(Pr^{141})$, the magnetic moment of $Ce^{141}$ is $\mu_N = 1.30 \pm 0.20$ nm and $\delta(E2/M1) = +0.066 \pm 0.022$. The spin of the 142-kev level of $Pr^{141}$ is established as $^7/_2$. The beta transition is predominantly $i_\beta = 0$. For the sequence $^7/_2(Ce^{143})(i_\beta = 0,1)^5/_2(^7/_2)(M1, E2, 294\ kev)^5/_2(^7/_2)$, the magnetic moment of $Ce^{143}$ is $|\mu_N| = 1.0 \pm 0.3$ nm, and $\delta(E2/M1) = -0.80 \pm 0.20$. The magnetic moments were found to be in agreement with configuration-mixing calculations. Evidence was found for two kinds of orientation attenuation in cerium magnesium nitrate. (auth)

**11706** HYPERFINE-STRUCTURE MEASUREMENTS ON SILVER-105. W. Bruce Ewbank and Howard A. Shugart (Univ. of California, Berkeley). Phys. Rev. 129: 1617-21. (Feb. 15, 1963). (UCRL-10406)

The hyperfine-structure separation in the $^2S_{\frac{1}{2}}$ electronic ground state of $Ag^{105}$ (40 day; $I = ^1/_2$) has been measured by atomic-beam methods. The result is $\Delta\nu = 1529.057(20)$ Mc/sec, assuming either a positive or a negative nuclear moment. Combining this measurement with the known constants of $Ag^{107}$ gives a nuclear magnetic moment of magnitude $|\mu_I|_{\text{uncorrected}} = 0.1009(10)$ nuclear magneton. (auth)

**11707** PARITY OF THE 2.13-Mev FIRST EXCITED STATE OF $B^{11}$. D. H. Wilkinson, D. E. Alburger, E. K. Warburton, and R. E. Pixley (Brookhaven National Lab., Upton, N. Y.). Phys. Rev., 129: 1643-8(Feb. 15, 1963). (BNL-6397)

The positron-electron pair-line spectrum of the 2.13-

Mev transition in $B^{11}$ has been measured by means of an intermediate-image pair spectrometer using the reaction $B^{11}(p,p')B^{11*}$ at the 2.66-Mev proton resonance. Comparison measurements were made on the pair line of the 3.09-Mev E1 transition in the $C^{12}(d,p)C^{13}$ reaction at $E_d = 1.7$ Mev. Gamma-ray yields from the two reactions were monitored by means of a 5-in. × 5-in. NaI crystal spectrometer. The ratio $R \equiv (N_{\text{pair line}}/N_\gamma)_{3.09}/(N_{\text{pair line}}/N_\gamma)_{2.13}$ was found to be 3.3 ± 0.7. Calculations of the spectrometer pairline efficiency versus transition energy were made for E0, E1 to E4, and M1 to M4 multipoles based on angular correlation formulas of Oppenheimer and of Rose. The values of R derived from the efficiency curves are 1.81, 3.51, 2.78, and 5.42 corresponding to E1, M1, E2, and M2 multipolarities, respectively, for the 2.13-Mev $B^{11}$ transition. The experimental result establishes that there is no parity change between the ground and first excited states and therefore that the latter is of odd parity since the ground state of $B^{11}$ is $\frac{3}{2}^-$. (auth)

**11708** NUCLEAR LEVEL DENSITIES AND REACTION MECHANISMS FROM INELASTIC NEUTRON SCATTERING. David B. Thomson (Los Alamos Scientific Lab., N. Mex.). Phys. Rev., 129: 1649-67(Feb. 15, 1963).

The continuous spectrum of fast neutrons scattered inelastically by each of twenty elements has been observed at an incident energy of 7.0 Mev. The elements range in mass number from 26 to 209. The neutron spectra were observed in the range of 0.5 to 4.0 Mev. Similar observations were made for many of the same elements at one or more lower values of incident energy ranging from 4.0 to 6.0 Mev. Angular distributions of the continuous spectra of 5.0 Mev neutrons scattered inelastically by niobium and indium were also measured. The results of the investigation are as follows: (1) Compound-nucleus formation is the predominant reaction mechanism, but direct interaction plays a significant role. (2) The inferred variations of nuclear level density indicate that the nuclear entropy varies with the excitation energy either linearly, as the square root, or in some intermediate fashion, and there is some evidence that the character of this result depends on the shell structure of the nucleus in question. (3) The inferred values of Fermi-gas single-particle level density increase with mass number in the regions between closed shells and go through marked minima near and at closed shells. (4) There is evidence that the effect of pairing is significant at the excitation energies studied. (auth)

**11709** VIRTUAL ELECTRON CAPTURE IN $Ni^{59}$. Marcel Schmorak (Brookhaven National Lab., Upton, N. Y.). Phys. Rev., 129: 1668-72(Feb. 15, 1963). (BNL-6399)

A careful measurement of the gamma-ray spectrum of $Ni^{59}$ has been performed. The analysis of the data indicates that the inner bremsstrahlung spectrum is slightly distorted near the endpoint. This distortion is ascribed to destructive interference with a virtual $e^-$ capture through the first excited state in $Co^{59}$. The probability of the virtual transition is found to be in the range of 0.0005 to 0.006 relative to the direct, second forbidden, inner bremsstrahlung to the ground state of $Co^{59}$. The product of the width of the first excited state in $Co^{59}$ and the log(ft) value for the virtual $e^-$ capture is determined. (auth)

**11710** PARTIAL-WAVE ANALYSIS OF THE INELASTIC SCATTERING OF ELECTRONS BY NUCLEI. II. APPLICATION TO THE LIQUID DROP MODEL. D. S. Onley, T. A. Griffy, and J. T. Reynolds (Duke Univ., Durham, N. C.). Phys. Rev., 129: 1689-90(Feb. 15, 1963).

A partial-wave analysis of the solution of the Dirac equation in a Coulomb field is used to calculate inelastic scattering from a nucleus treated as an inhomogeneous charged liquid drop. Using charge density functions obtained from elastic electron scattering, the form factors for quadrupole excitation of the nuclei $Ni^{58,60}$ and $Sr^{88}$ are calculated and found to display better agreement with experimental results than the usual Born approximation. To show the expected effects of a large Coulomb field, a similar calculation for $Bi^{209}$ is also included. (auth)

**11711** GAMMA-RAY SPECTRUM FROM THERMAL-NEUTRON CAPTURE IN $Hf^{177}$ AND ASSOCIATED ENERGY LEVELS IN $Hf^{178}$. R. K. Smither (Argonne National Lab., Ill.). Phys. Rev., 129: 1691-1708(Feb. 15, 1963). (TID-16196; UAC-6403)

The gamma-ray spectrum resulting from thermal-neutron capture in $Hf^{177}$ was investigated with the Argonne 7.7-m bent-crystal spectrometer. The observed spectrum consisted of 217 gamma rays with energies between 50 kev and 1.6 Mev. These precision measurements of gamma-ray energies and intensities were used to modify and extend the level scheme of $Hf^{178}$. The proposed level scheme of $Hf^{178}$ contains the following 20 levels (the energy of the level being given in kev followed by the K value, spin, and parity of the level): ground state [0,$0^+$]; 93.17 [0,$2^+$]; 306.59 [0,$4^+$]; 632.10 [0,$6^+$]; 1058.3 [[0,$8^+$]]; 1196.27 [0,$0^+$]; 1237.26 [[0,$0^+$]]; 1269.34 [0,$2^+$]; 1233.85 [0,$2^+$]; 1384.48 [[ ,4]]; 1402.25 [2,$2^+$]; 1420.64 [2,$2^+$]; 1431.25 [0,$0^+$]; 1473.13 [(1,$1^+$) or (2,$2^+$)]; 1473.32 [0.$4^+$]; 1512.92 [0,$4^+$]; 1514.56 [[ ,$2^+$]]; 1550.02 [[2,$3^+$]]; 1569.78 [[2,$3^+$]]; and 1575.73 [[0,$2^+$]]. The double brackets indicate an uncertainty in the assignments. (auth)

**11712** $Ba^{131m}$—A NEW ISOMER. R. S. Tilbury and L. Yaffe (McGill Univ., Montreal). Phys. Rev., 129: 1709-12(Feb. 15, 1963).

A new isomer of $Ba^{131}$ with a half life of 14.5 min has been produced by the reaction $Cs^{133}(p,3n)Ba^{131m}$. The mass assignment has been made by excitation functions and from cross bombardments using the reaction $I^{127}(Li^7,3n)Ba^{131m}$. The isomer decays by emission of a 106 ± 4 kev γ ray. The growth of the $Ba^{131}$ ground-state γ rays has been observed, consistent with a 14.5-min parent. No decay (<0.1%) has been observed directly to $Cs^{131}$. (auth)

**11713** CHARACTERISTICS OF THE DECAY OF $Ba^{131m}$. D. J. Horen, W. H. Kelly, and L. Yaffe (Univ. of California, Berkeley). Phys. Rev., 129: 1712-15(Feb. 15, 1963). (UCRL-10413)

Sources of $Ba^{131m}$ were produced by bombarding sodium iodide with $Li^7$ ions of about 38-Mev energy, and its half life was redetermined as 14.6 ± 0.2 min. Its decay was studied by means of scintillation techniques. The decay of $Ba^{131m}$ proceeds by a (78 ± 5)-kev E3 transition ($\alpha_K$ = 12.3 ± 1.5), followed by a (107 ± 3)-kev M1 + E2 transition ($\alpha_K$ = 0.90 ± 0.15). Included is a discussion of possible spin and parity assignments for the levels involved in this decay. An auxiliary experiment showed that less than 1% of $La^{131}$ decays lead to $Ba^{131m}$. (auth)

**11714** $C^{13}(p,\gamma)N^{14}$ REACTION AND THE 9.17-, 7.03-, AND 6.44-Mev STATES IN $N^{14}$. F. W. Prosser, Jr., R. W. Krone, and J. J. Singh (Univ. of Kansas, Lawrence). Phys. Rev., 129: 1716-22(Feb. 15, 1963).

A re-examination of the γ-ray decay of the 9.17-Mev state in $N^{14}$, reached at the 1.75-Mev resonance in the $C^{13}(p,\gamma)N^{14}$ reaction, has confirmed the shell-model assignments previously given to that state and the 7.03-Mev state. The observation of a weak transition to the 2.31-Mev state supports the positive parity assignment of the

9.17-Mev state. Angular distribution and correlation measurements indicate an amplitude ratio of f wave to p wave in the formation of the compound state of $-0.70 \pm 0.26$ and E2/M1 amplitude ratios of $-0.005 \pm 0.020$ and $-0.6 \pm 0.1$ for the 9.17 → ground-state and 7.03 → ground-state transitions, respectively. A slight preference for a positive parity assignment for the 6.44-Mev state is found. The results, in general, are in good agreement with the calculations of Warburton and Pinkston. The alternative shell-model configurations suggested by them for the 6.44-Mev state are examined, but existing data are found to be inconclusive. (auth)

**11715** THRESHOLDS OBSERVED IN THE $C^{12}(\alpha,n)O^{15}$, $Si^{28}(\alpha,n)S^{31}$, $S^{32}(\alpha,n)Ar^{35}$, $S^{34}(\alpha,n)Ar^{37}$, AND $Cl^{35}(p,n)Ar^{35}$ REACTIONS. J. W. Nelson, E. B. Carter, G. E. Mitchell, and R. H. Davis (Florida State Univ., Tallahassee). Phys. Rev., 129: 1723-7(Feb. 15, 1963).

The following thresholds have been measured in the $(\alpha,n)$ reaction: $C^{12}$ 11.341 ± 0.015; $Si^{28}$ 9.30 ± 0.05, 10.55 ± 0.05, 11.83 ± 0.05, 12.78 ± 0.05; $S^{32}$ 9.846 ± 0.020, 10.69 ± 0.05, 11.97 ± 0.08; $S^{34}$ 5.17 ± 0.10, 5.96 ± 0.05, 6.90 ± 0.05, 8.04 ± 0.05, 9.09 ± 0.05, 10.09 ± 0.05, 10.31 ± 0.05 Mev. These results are in agreement with previously published results except for the $S^{32}(\alpha,n)Ar^{35}$ ground threshold which is 140 kev higher than expected. To confirm the value of the mass of $Ar^{35}$, the $Cl^{35}(p,n)Ar^{35}$ threshold energy was measured and is 6.942 ± 0.020 Mev. Since this result agrees with the accepted value of the $Ar^{35}$ mass, the 140-kev discrepancy was not resolved. In the $C^{12}(\alpha,n)O^{15}$ excitation curve a prominent resonance of half-width 220 ± 60 kev was found corresponding to a level in $O^{16}$ of excitation 18.10 ± 0.06 Mev. The cross section rises to about 22 mb at the peak of this resonance. Half-life determinations yielded the values: $O^{15}$ 122.6 ± 1.0, $S^{31}$ 2.56 ± 0.10, and $Ar^{35}$ 1.76 ± 0.03 sec. (auth)

**11716** ANGULAR DISTRIBUTIONS OF (n,d) PICKUP REACTIONS IN $N^{14}$, $P^{31}$, AND $S^{32}$ AT 14 Mev. M. R. Zatzick and D. R. Maxson (Brown Univ., Providence). Phys. Rev., 129: 1728-36(Feb. 15, 1963). (TID-17088)

A double proportional counter-scintillator telescope was employed to study the angular distributions of deuterons produced by 14.1-Mev neutron-induced pickup reactions on natural targets of $N^{14}$, $P^{31}$, and $S^{32}$. Measurements were taken at intervals of 5 to 15° over the laboratory range 0 to 150°. Simultaneous measurements of E and dE/dx permitted separation of particles of different Z/M. Five angular distributions of deuterons corresponding to three ground-state and two excited-state transitions were obtained. Absolute center-of-mass differential cross sections were assigned. Neither significant isotropic contributions nor back-angle yields were observed. All spin and parity assignments were consistent with accepted values. Absolute reduced widths were extracted by the peak-fitting method and the Amado extrapolation procedure. Comparison of experimental and jj shell-model S values (relative reduced widths), in addition to observed jj-forbidden transitions, clearly indicated appreciable core excitations in the ground state configurations of $P^{31}$ and $S^{32}$. The $S^{32}(n,d)P^{31}$ (gnd.) measurements revealed a gross discrepancy in a previously reported cross section for the inverse $P^{31}(d,n)S^{32}$ reaction. An anomalously large reduced width for the transition to the 3.68-Mev level of $C^{13}$ was qualitatively confirmed. (auth)

**11717** DECAY OF $Re^{184}$ ISOMERS AND THE LEVEL SCHEME IN $W^{184}$. Noah R. Johnson (Oak Ridge National Lab., Tenn.). Phys. Rev., 129: 1737-50(Feb. 15, 1963).

The decay properties of a rhenium activity followed for over five years have led to its assignment to $Re^{184}$ with isomeric states of 33 ± 3 and 169 ± 8 days. An unidentified rhenium species with a half-life ≥ 21 years is also present in very small abundance. Energies (and intensities) of the gamma rays determined from the single-crystal and coincidence studies are 0.059(146), 0.111(27.3), 0.163(1.8), 0.217(4.4), 0.253(7.0), 0.318(1.7), 0.384(1.2), 0.539(0.9), 0.540(0.8), 0.641(3.3), 0.770(1.5), 0.793(64.6), 0.894(25.2), 0.904(71.7), 0.909(3.1), 0.97(0.8), 1.03(1.1), 1.04(0.05), 1.16(0.5), and 1.28(0.2) Mev. Gamma coincidence spectra were measured by gating on every gamma-ray peak in the single-crystal spectrum. The 163-kev gamma ray and most of the intensity of the peak at 217 kev appear to be associated with levels in $Re^{184}$, where the latter energy represents the isomeric transition from the 169-day state. Levels (and spins) in $W^{184}$ are proposed at 0.111(2+), 0.364(4+), 0.748(6+), 1.287(8+), all members of the ground-state rotational band; 0.904(2+), 1.005(3+), 1.134(4+), members of the γ-vibrational band; 1.222, 1.273, 1.33, and 1.40 Mev. $Re^{184}$ levels are assigned at 0.163 and 0.217 Mev. The difference between the experimental and theoretical reduced transition probability ratios from the γ-vibrational to the ground-state rotational band are accounted for by a mixing of the two bands. (auth)

**11718** BOMBARDMENT OF $C^{12}$ BY $Li^6$ IONS. S. Bashkin, V. P. Hart, and W. A. Seale (State Univ. of Iowa, Iowa City). Phys. Rev., 129: 1750-1(Feb. 15, 1963).

Thin, self-supporting carbon films have been bombarded by $Li^6$ ions with an incident energy of 3 Mev. Relative angular distributions have been determined for alpha particles leading to the ground state of $N^{14}$, deuterons to the ground state of $O^{16}$, and protons to the second, third, and fourth excited states of $O^{17}$. (auth)

**11719** NUCLEAR PROPERTIES OF $Eu^{145}$, $Eu^{146}$, $Eu^{147}$, $Gd^{146}$, AND $Gd^{147}$. A. M. Friedman, J. Milsted, and O. Skilbreid (Argonne National Lab., Ill.). Phys. Rev., 129: 1752-3(Feb. 15, 1963). (TID-17417)

Samples of isotopically pure $Eu^{145}$, $Eu^{146}$, $Eu^{147}$, $Gd^{146}$, and $Gd^{147}$ were prepared by bombardment of $Sm^{144}$ and subsequent separation. The gamma spectrum of each is given and compared to the literature values. (auth)

**11720** EFFECTS OF CONFIGURATION MIXING ON THE $3^-$ STATE OF $Pb^{208}$ AND THE (p,p') REACTION IN THE DISTORTED-WAVE APPROXIMATION. D. C. Choudhury (Univ. of Connecticut, Storrs and Oak Ridge National Lab., Tenn.). Phys. Rev., 129: 1754-61(Feb. 15, 1963).

It is shown that the experimental mean life of the first excited $3^-$ state of $Pb^{208}$ can be approximately accounted for if configuration mixing is introduced instead of considering this state as a pure single-particle shell-model state. For this purpose an octupole-octupole force is assumed (an extension of the quadrupole-quadrupole force of Elliott). Further, the direct interaction theory of inelastic scattering in the distorted-wave Born approximation is used to calculate the cross section of 23-Mev protons for excitation of the 0.57-Mev and 0.90-Mev levels of $Pb^{207}$ [corresponding to the transitions $(p_{\frac{1}{2}})^{-1} \rightarrow (f_{\frac{5}{2}})^{-1}$ and $(p_{\frac{1}{2}})^{-1} \rightarrow (p_{\frac{3}{2}})^{-1}$, respectively] and for excitation of the anomalous peak at 2.6 Mev ($3^-$ state of $Pb^{208}$) using the configuration-mixed nuclear wave function. It is suggested that the anomalous peak at 2.6 Mev for $Pb^{206}$ and $Pb^{207}$ is also due to superposition of many single-particle transitions as in $Pb^{208}$. As a result of the configuration mixing, reasonable agreement is obtained between the experimental and theoretical cross sections for the above-mentioned cases. Finally, various suggestions which can lead to better understanding of this process are made. (auth)

**11721** $He^3$ REACTIONS ON $B^{11}$ AND $N^{14}$. A. Gallmann, D. E. Alburger, D. H. Wilkinson, and F. Hibou (Institut de Recherches Nucléaires, Strasbourg). Phys. Rev., 129: 1765-70(Feb. 15, 1963).

The $\frac{5}{2}^-$ level expected in the mass-13 nuclei according to shell-model calculations has been searched for by magnetic analysis of the $B^{11}(He^3,p)C^{13}$ and $N^{14}(He^3,\alpha)N^{13}$ reactions using a broad-range magnetic spectrograph. Up to an excitation energy of 7.9 Mev in $C^{13}$ and 7.0 Mev in $N^{13}$, no new levels have been found. $C^{13}$ states reported previously at 5.51 and 6.10 Mev in the $B^{11}(He^3,p)C^{13}$ reaction have not been confirmed. The apparent absence of a $\frac{5}{2}^-$ state up to ≈7 Mev excitation suggests that the intermediate coupling parameter $\alpha/K$ may be smaller than presupposed. In an investigation of the $B^{11}(He^3,\alpha)B^{10}$ reaction the 5.11 to 5.16 Mev doublet was not resolved. $B^{10}$ levels reported previously at 2.86, 5.58, and 6.40 Mev have not been confirmed by studies of this reaction. (auth)

**11722** $Li^6$ AND $Li^7$(n,2n) CROSS SECTIONS. V. J. Ashby, H. C. Catron, M. D. Goldberg, R. W. Hill, J. M. Le Blanc, L. L. Newkirk, J. P. Stoering, C. J. Taylor, and M. A. Williamson (Univ. of California, Livermore). Phys. Rev., 129: 1771(Feb. 15, 1963). (UCRL-6991)

Absolute measurements of the 10.2- and 14.1-Mev (n,2n) cross sections of $Li^6$ and $Li^7$ have been made using the large scintillator technique. The cross sections in barns obtained for $Li^6$ are: 0.033 ± 0.015 at 10.2 Mev and 0.070 ± 0.006 at 14.1 Mev. The $Li^7$ cross sections are: 0.027 ± 0.015 at 10.2 Mev and 0.056 ± 0.005 at 14.1 Mev. (auth)

**11723** RADIOACTIVE DECAY OF $Zn^{72}$. T. T. Thwaites (Pennsylvania State Univ., University Park). Phys. Rev., 129: 1778-81(Feb. 15, 1963).

The decay of $Zn^{72}$ (46.5h) has been investigated using standard scintillation counter techniques. Samples of $Zn^{72}$ were obtained from the fission of $Th^{232}$ and $Ta^{181}$ by fast protons. Gamma rays of 51 ± 3, 143 ± 2, and 192 ± 4 kev were observed. A beta-ray group of 296 ± 6 kev was found in the singles and in coincidence with the 143-kev gamma. A decay scheme is proposed for $Zn^{72}$. (auth)

**11724** SHAPE OF THE $0^+ \rightarrow 0^+$ POSITRON SPECTRUM IN $Ga^{66}$. D. C. Camp and L. M. Langer (Indiana Univ., Bloomington). Phys. Rev., 129: 1782-9(Feb. 15, 1963).

A detailed study of the beta spectrum of $Ga^{66}$ with emphasis on the shape of the positron spectrum of the $0^+ \rightarrow 0^+$ transition has been made with a magnetic spectrometer. The ground-state to ground-state transition is found to have a nonstatistical shape. The shape factor is fitted by the equation $S(W) = K(1 + 0.0328W + 0.354/W - 0.000419W^2)$ based upon a ratio of matrix elements $\lambda = \langle i\alpha \cdot \hat{r} \rangle / \langle 1 \rangle = -21.3$. An additional factor of the form $(1 + 0.4/W)$ is needed to obtain the best fit. The nonstatistical shape for this group leads to an end-point energy of 4.153 ± 0.003 Mev and an intensity of 51.2%. The log ft is 7.903 and from this the amount of T =3 admixture in the T = 2 ground state of $Ga^{66}$ is found to be $4.00 \times 10^{-5}$. (auth)

**11725** EXCITATION FUNCTIONS AND NUCLEAR CHARGE DISPERSION IN THE FISSION OF URANIUM BY 0.1- TO 6.2-Gev PROTONS. G. Friedlander, L. Friedman, B. Gordon, and L. Yaffe (Brookhaven National Lab., Upton, N. Y.). Phys. Rev., 129: 1809-25(Feb. 15, 1963). (BNL-6404)

Cross sections for formation of cesium and rubidium isotopes produced by bombardment of uranium with protons ranging in energy from 0.1 to 6.2 Bev were measured both radiochemically and mass spectrometrically. Independent yields were determined for $Rb^{84}$, $Rb^{86}$, $Cs^{127}$, $Cs^{129}$, $Cs^{130}$, $Cs^{131}$, $Cs^{132}$, $Cs^{134}$, $Cs^{136}$, and, at some energies, $Rb^{83}$ and $Cs^{135}$. In addition, the independent yield of $Ba^{131}$ and the chain yields of $Cs^{125}$, $Cs^{127}$, $Cs^{129}$, $La^{131}$, $Cs^{135}$, $Cs^{137}$, $Rb^{83}$, $Rb^{87}$, and $Ba^{140}$ were obtained. The formation cross sections of the Cs and Ba products on the neutron-excess side of stability decrease monotonically with increasing energy above 0.1 Bev, whereas the excitation functions for independent formation of the more neutron-deficient products in the Cs-Ba region and of $Rb^{84}$ and $Rb^{86}$ all go through maxima. The proton energies at which these maxima occur fall on a smooth curve when plotted against the neutron-proton ratio of the product, with the peaks moving to higher energies with decreasing neutron-proton ratio. Under the assumption that the mass-yield curve in the region $125 < A < 140$ is rather flat at each proton energy, the cross-section data in the Cs region can be used to deduce the charge dispersion in this mass range. Plots of $\log\sigma$ vs $N/Z$ (or $Z - Z_A$) show symmetrical bell-shaped peaks up to a bombarding energy of 0.38 Bev, with full width at half-maximum increasing from 3.3 Z units at 0.10 Bev to about 5 Z units at 0.38 Bev, and with the peak position ($Z_p$) moving from $Z_A - 1.44$ to $Z_A - 0.85$ over the same energy range. At all higher energies, a double-peaked charge distribution was found, with a neutron-excess peak centered at $N/Z \sim 1.515 (Z_p \sim Z_A - 1.9)$, and having approximately constant width and height at bombarding energies greater than 1 Bev. The peak on the neutron-deficient side which first becomes noticeable at 0.68 Bev appears to become broader and shift slightly to smaller N/Z values with increasing energy. The two peaks are of comparable height in the Bev region, and the peak-to-valley ratio is only ~2. The total formation cross section per mass number in the Cs region decreases from ~52 mb at 0.1 Bev to about 29 mb at 1 Bev and then stays approximately constant; the contribution of the neutron-excess peak above 1 Bev is about 12 mb. The neutron-excess peak corresponds in width and position to that obtained in fission by ~50-Mev protons. The recoil behavior of $Ba^{140}$ lends support to the idea that the neutron-excess products are formed in a low-deposition-energy process. The recoil behavior of $Ba^{131}$ indicates that it is formed in a high-deposition-energy process. Post-fission neutron evaporation is required for the observed characteristics of the excitation functions of the rubidium isotopes and the neutron-deficient species in the Cs region. The correlation between neutron-proton ratios and positions of excitation function maxima is semi-quantitatively accounted for if fission with unchanged charge distribution, followed by nucleon evaporation, is assumed. (auth)

**11726** CROSS SECTION AND RECOIL STUDIES OF REACTION OF $U^{238}$ WITH PROTONS OF 0.5 TO 6.2 Gev. John M. Alexander, Christiane Baltzinger, and M. Frances Gazdik (Univ. of California, Berkeley). Phys. Rev., 129: 1826-34(Feb. 15, 1963). (UCRL-10268)

Radiochemical investigations of $Cu^{64,67}$, $Mo^{99}$, $Ag^{111}$, $Pd^{112}$, and $I^{121-135}$ produced from irradiations of $U^{238}$ with high-energy protons are reported. Cross sections are given for proton energies between 0.5 and 6.2 Bev. Recoil properties from thick targets are reported for irradiations with 0.72- and 6.2-Bev protons. All the products investigated at 0.72 Bev result from nuclear fission. Deposition energies of the same order as calculated for all nucleon-nucleon collision cascades. Excitation functions and the relative values of the deposition energies are reasonably well reconciled with nucleonic cascade followed by fission. Proton irradiations at 6.2 Bev produce $Mo^{99}$, $Ag^{111}$, $Pd^{112}$, and $I^{131-135}$ by nuclear fission after depositing an average of <200 Mev in the

struck nuclei. $Cu^{64}$ is probably not produced by binary fission. The neutron-deficient iodine isotopes are probably produced by a fast process. A correlation is suggested with fragment (A ≈ 20 to 60) production. (auth)

**11727** NUCLEAR CHARGE DISTRIBUTIONS IN THE INTERACTION OF 2.9-Gev PROTONS WITH HEAVY ELEMENTS. Sheldon Kaufman (Brookhaven National Lab., Upton, N. Y. and Princeton Univ., N. J.). Phys. Rev., 129: 1866-72(Feb. 15, 1963). (PPAD-463E)

Cross sections for the formation of a number of nuclides in the mass range 65 to 74 in the bombardment of In, Au, and U with 2.9 Bev protons have been measured. Four isobars of mass 72, three of mass 67, and three of mass 66 are included. Charge distribution curves have been constructed from the data, using N/Z the ratio of neutrons to protons in the nucleus, as abscissa. The curves are not symmetric about the peak, falling less steeply toward large N/Z, with U having the most asymmetry. The peak position shifts to larger N/Z as the target mass increases. The data for In are consistent with a cascade-evaporation mechanism involving a long evaporation sequence, while the U data show the importance of low-excitation-energy fission in the formation of neutron-excess nuclides. (auth)

**11728** NEW $\beta^-$ ACTIVITY INDUCED BY PHOTON BOMBARDMENT OF LITHIUM. B. M. K. Nefkens (Purdue Univ., Lafayette, Ind.). Phys. Rev. Letters, 10: 55-56 (Jan. 15, 1963).

A pure Li target of natural abundance is exposed to the bremsstrahlung beam of a 320-Mev synchrotron. A beta activity with a maximum energy above 15 Mev and a half life of 110 msec is observed. This activity is conjectured to come from $H^5$, produced in the reaction $Li^7(\gamma,2p)H^5$. Assuming the beta particle to result from decay to the ground state of $He^5$, a log ft value of 5.4 ± 0.1 is obtained (if the branching ratio is assumed to be 90% for this decay mode). (T.F.H.)

**11729** EXTENSIVE ROTATIONAL STRUCTURE IN THE ODD-ODD DEFORMED NUCLEUS $Ho^{166}$. Gordon Lee Struble, Neil Shelton, and Raymond K. Sheline (Florida State Univ., Tallahassee). Phys. Rev. Letters, 10: 58-60 (Jan. 15, 1963).

A spectroscopic analysis based on the reaction $Ho^{165}(d,p)Ho^{166}$ is used to determine the energy levels of $Ho^{166}$. Thirty-one levels are observed below 818 kev, 22 of which fit into four rotational bands. Three of these bands result from the two lowest-energy Nilsson configurations. Conclusions regarding the moments of inertia, spins, energies, and systematics of the excited states and rotational bands are summarized. (T.F.H.)

**11730** LARGE $He^3$ NUCLEAR POLARIZATION. L. D. Schearer, F. D. Colegrove, and G. K. Walters (Texas Instruments Inc., Dallas). Phys. Rev. Letters, 10: 108-10 (Feb. 1, 1963).

Nuclear polarization of 40% was attained in $He^3$ gas at room temperature by optical pumping techniques. Substantial $He^3$ polarization at moderate pressures and in a favorable environment made possible nuclear scattering experiments involving $He^3$ targets. The polarization obtained in a particular experimental arrangement depended on the $He^3$ sample pressure, on sample geometry, and on the character of the resonance radiation employed for optical pumping. These factors and the means for measuring the polarization were discussed. (C.E.S.)

**11731** IMPULSE APPROXIMATION AND DISTORTED WAVES. Larry Zamick (Princeton Univ., N. J.). Phys. Rev. Letters, 10: 117-19(Feb. 1, 1963).

An expression for the amplitude of a nucleon-nucleus inelastic scattering at high energies was derived. This expression eliminated troublesome terms that involve the mixing of the two-body interaction and the distorting potential. (C.E.S.)

**11732** ON THE COLLECTIVE MOTION IN EVEN-EVEN DEFORMED NUCLEI. Toshio Marumori, Masatoshi Yamamura, and Hiroharu Bandō (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 28: 87-104(July 1962). (In English)

By beginning with a spherically symmetric j-j coupling shell-model Hamiltonian with a general effective two-body interaction, formulas for various empirical parameters characterizing the collective motion in even-even deformed nuclei are given, with explicit reference to the effective interaction. An adiabatic approximation is assumed that is the same as that underlying the Bohr strong-coupling model and its modifications. Characteristics of various collective modes described in these phenomenological models are investigated, and the physical implication underlying the models is made clear. Discussions are made in as general a form as possible and, to make the results clearer, simple estimates based on the so-called "Pairing plus Quadrupole Force" are made for each case. (auth)

**11733** EFFECT OF THE TENSOR FORCE ON THE PHOTONUCLEAR SUM RULE. Kazuto Okamoto and Kenji Hasegawa (Tohoku Univ., Sendai). Progr. Theoret. Phys. (Kyoto), 28: 137-50(July 1962). (In English)

The effect of the two-body correlation including the tensor force on photonuclear cross sections is discussed using the sum-rule calculation. The two-body interaction is assumed to be of the central plus tensor potential, both of which are partly of the Majorana exchange type and partly of Gaussian shape without a hard core, the parameters of which are taken from an analysis of two-nucleon scattering. The calculation is performed by first order perturbation. The integrated cross section is found to increase by several tens of percent from the value of the independent-particle model. The result is not inconsistent with experiments. The bremsstrahlung-weighted cross section is not affected by the tensor force in this order of approximation. (auth)

**11734** EXCITATION OF COLLECTIVE MOTION OF THE GIANT PHOTONUCLEAR RESONANCE BY PROTONS. Michel Fabre de la Ripelle (Laboratoire de Physique Nucléaire, Orsay, France). Progr. Theoret. Phys. (Kyoto), 28: 151-62(July 1962). (In French)

In the framework of a collective model, in which a Fermi distribution is used to describe the intrinsic part, the calculus of the excitation of the giant dipole photonuclear resonance by protons is given by the Born approximation. It is found that the excitation appears only for proton scattering angles strongly pointed in the forward direction, depends mainly on the nuclear form factor, and is only effective in the triplet-even and singlet-odd interaction. Theoretical curves are obtained by utilizing the Gammel-Thaler potential and the electron-scattering form factor. (auth)

**11735** ON SUPERFLUIDITY AND PHASE TRANSITION IN ATOMIC NUCLEUS. K. M. Khanna (Indian Inst. of Tech., Kharagpur). Progr. Theoret. Phys. (Kyoto), 28: 205-7 (July 1962). (In English)

Assuming the existence of an energy gap and the validity of the shell model at low excitations, residual interactions of nucleons situated near the Fermi energy surface are calculated. From these interactions, the nuclear thermodynamic potential is calculated by variational techniques. This potential is used to determine the superfluid properties and normal-superfluid transition temperature of the nucleus. (T.F.H.)

**11736** QUASI-ELASTIC SCATTERING. Yoshiyuki Sakamoto (Univ. of Uppsala). Progr. Theoret. Phys. (Kyoto), 28: 803-8(Nov. 1962). (In English)

The effects of distortion due to the nuclear potential are considered in the quasi-elastic scattering. The Hart-Montroll scattering waves in a square-well potential are used to take account of the distortion. Good fits with experimental data are shown for the quasi-elestic scattering of $C^{12}$. (auth)

**11737** SEMICLASSICAL ANALYSIS OF THE MULTI-NUCLEON TRANSFER REACTIONS BETWEEN COMPLEX NUCLEI. Tetsuo Kammuri (Osaka Univ.). Progr. Theoret. Phys. (Kyoto), 28: 934-41(Nov. 1962). (In English)

The angular distributions of reactions in which several nucleons are exchanged between complex nuclei are examined in a semiclassical way. It is assumed that since the projectile interacts weakly with the target in a grazing trajectory, it passes through a target along the elastic scattering orbit, while exchanging several nucleons, and finally shows itself as a product of the transfer reaction. The distortion of the Coulomb scattering orbit due to nuclear potential is taken into account. Then for grazing collisions the nuclear and Coulomb forces counteract each other, emitting a particle in a forward direction as observed in experimental data. (auth)

**11738** CONCERNING THE PRODUCTION OF $Si^{32}$ BY A (t,p) PROCESS. D. Geithoff (Kernforschungszentrum Karlsruhe, Ger.). Radiochim. Acta, 1: 3-6(Sept. 1962). (KFK-115). (In German)

Tritons produced by the process $Li^6(n,t)He^4$ were used to obtain the long-lived $Si^{32}$ by means of the reaction $Si^{30}(t,p)Si^{32}$. The identity of the nuclide was proved by means of separation and identification of the daughter $P^{32}$ and by the growth of the daughter activity in the $Si^{32}$ sample following a silicon-phosphorus separation. A comparison of the probabilities of the reactions $Mg^{26}(t,p)Mg^{28}$ and $Si^{30}(t,p)Si^{32}$ led to a value of 650 years for the half life of $Si^{32}$. (auth)

**11739** EFFECTIVE INTERACTIONS AND COUPLING SCHEMES IN NUCLEI. Igal Talmi (Princeton Univ., N. J.) Rev. Mod. Phys., 34: 704-22(Oct. 1962).

Shell-model calculations of nuclear energy levels can be carried out only by using effective interactions between the nucleons. The information obtained from nuclei about the effective interaction is presented. The general properties of this interaction are discussed as well as their implications on the coupling scheme in nuclei. (W.D.M)

**11740** THEORY OF LOW ENERGY NUCLEAR REACTIONS. Erich Vogt (Atomic Energy of Canada Ltd., Chalk River, Ont.). Rev. Mod. Phys., 34: 723-47(Oct. 1962).

The principal features of the theory of resonance reactions are described in terms of simple examples. A straightforward derivation is given of the particular result for the collision matrix found recently to be most useful for the description of low energy nuclear reactions. This result is expressed in terms of the potential scattering phase shifts and in terms of the level widths and level shifts of the compound nucleus states. The effect of the diffuse nuclear edge on low energy nuclear reactions is discussed in detail. (W.D.M.)

**11741** POLARIZATION DISTRIBUTION OF FAST NEUTRONS ELASTICALLY SCATTERED ON C-12. A. Kalboryanu and I. Mynzatu (Inst. of Nuclear Physics, Bucharest). Rev. Phys., Acad. Rep. Populaire Roumaine, 7: 433-6(1962). (In Russian)

Polarization of neutrons elastically scattered on $C^{12}$ at 1.45 to 4.10 Mev was studied, and the results showed considerable variations at 2.076, 2.95, and 3.75 Mev at 60°. (R.V.J.)

**11742** STRIPPING REACTION ON CHROMIUM ISOTOPES. P. G. Ivanitskii (Inst. of Physics, Kiev). Ukr. Fiz. Zh., 7: 1023-4(Sept. 1962). (In Ukrainian)

Studies were made of a 13.6-Mev deuteron stripping on single-isotope targets with an average nuclear mass of A ~ 60, and distributions of protons from stripping reactions on $Cr^{50}$, $Cr^{52}$, $Cr^{53}$, and $Cr^{54}$ were determined. (R.V.J.)

**11743** PROTON SCATTERING ON Mg-24 AT 6.9 Mev. O. P. Klyrecharev, B. F. Orlenko, V. S. Prokopenko, and M. M. Pucherov (Inst. of Physics, Kiev). Ukr. Fiz. Zh., 7: 1028(Sept. 1962). (In Ukrainian)

Angular distributions of elastic and inelastic 6.9-Mev proton scattering on 99.5% enriched $Mg^{24}$ was studied using a scintillation spectrometer. The Q values for elastic and inelastic scattering are O and −1.37, respectively. (R.V.J.)

**11744** THE RELATIVE ISOTOPIC POSITION OF $Os^{186}$. G. Noeldeke, A. Steudel, K. E. Wallach, and H. Walther (Universität, Heidelberg). Z. Physik, 170: 22-5(1962). (In German)

Using three different samples of $Os^{192}$, $Os^{190}$, and $Os^{186}$ enriched to 98.68, 95.46, and 61.27%, respectively, the isotopic shifts $\Delta\nu(Os^{192} - Os^{190})$ and $\Delta\nu(Os^{192} - Os^{186})$ were measured in four Os I lines with a recording Fabry-Perot spectrometer. The relative isotopic position of $Os^{186}$ was found to be $\Delta\nu(Os^{192} - Os^{186})/\Delta\nu(Os^{192} - Os^{190}) = 3.52 \pm 0.03$. (auth)

**11745** DELBRÜCK SCATTERING OF 17-Mev PHOTONS. U. Stierlin, W. Scholz, and B. Povh (Universität, Freiburg i B.). Z. Physik, 170: 47-61(1962). (In German)

Differential cross sections were measured for the small angle scattering of $\gamma$ rays by iron, silver, tantalum, lead, and uranium with 17-Mev photons from $Li^7(p,\gamma)Be^8$ at mean four momentum transfers q of 0.5 mc and 1.3 mc and with 7-Mev photons from $F^{19}(p,\alpha\gamma)O^{16}$ at mean four momentum transfer of 0.5 mc. Under these experimental conditions only Compton, Rayleigh, and possibly Delbrück scattering are of importance. Extrapolation of known theoretical results to higher energies shows, that Rayleigh and Compton scattering from bound electrons should depend only on q for small angles, small q, and fixed Z. Using this it follows, that at 17 Mev and q ≈ 0.5 mc an additional scattering process must be present, which increases with growing Z and which is negligible in the measurements at 17 Mev with q ≈ 1.3 mc and at 7 Mev with q ≈ 0.5 mc. The results are in qualitative agreement with the approximate theory for Delbrück scattering of Bethe and Rohrlich, however experimental cross sections at 17 Mev and q ≈ 0.5 mc are about a factor of 1.6 lower than those predicted by this theory. This discrepancy is not unexpected, since exact calculations of Delbrück scattering amplitude from Kessler and Zernik at 2.62 Mev and 6.14 Mev show even greater deviations in the same sense. (auth)

**11746** PRODUCTION AND INVESTIGATION OF NEGATIVE FISSION PRODUCT IONS. Friedrich H. Froehner (Technische Hoshschule, Munich). Z. Physik, 170: 62-75 (1962). (In German)

Fragments from thermal fission of $U^{235}$ were slowed down in purified Ar and $N_2$. Ionization by reactor radiation produced sufficient free electrons in the gas to permit formation of negative fission product ions by electron attachment. These negative ions were collected in an ionization chamber. The $\gamma$ radiation of the activated electrode showed that

mainly I and Te were collected. By analysis of the $\gamma$ spectra, the independent fission yields $\eta(I^{135}) = 4.6 \pm 1.1\%$ and $\eta(Te^{135}) = 1.5 \pm 1.1\%$ were found. In the derivation of this result an estimated value $\eta(Te^{134}) = 6 \pm 0.7\%$ was used. (auth)

**11747** DECAY OF $Cl^{38}$ ISOMERS. P. Kienle, K. Wien, F. Wunderlich, and R. Haas (Technische Hochschule, Munich). Z. Physik, 170: 76-81(1962). (In German)

$Cl^{38m}$ was produced by neutron activation of chlorine-containing samples in a pneumatic irradiation facility. The decay of the $Cl^{38}$ isomer was investigated by various scintillation spectrometer technics. The half life and the internal conversion coefficient $\alpha$ of the 0.66 Mev isomeric transition was found to be $T_{1/2} = 0.74 \pm 0.03$ sec and $\alpha = (5.0 \pm 1.2) \times 10^{-4}$. These data suggest a M-3 transition between an isomeric state and the spin $I = 5^-$ and the ground state of Cl-38 ($I = 2^-$). (auth)

**11748** THE POTENTIAL ENERGY OF THE $\gamma$ OSCILLATIONS IN DEFORMED gg NUCLEI. Amand Faessler and Walter Greiner (Universität, Freiburg i B.). Z. Physik, 170: 105-13(1962). (In German)

By transformation of the collective Hamiltonian from the laboratory system to the intrinsic system one obtains an anharmonic term in the potential energy, if one chooses the volume element to be $d\tau(a_0a_2) = da_0da_2$. The consequence of this term on energies and transition probabilities are discussed. (auth)

**11749** MEASUREMENT OF THE PHOTOPROTON SPECTRUM FROM $C^{12}$ WITH A SEMICONDUCTOR DETECTOR. K. O. Hermann and J. A. Scheer (Universität, Heidelberg). Z. Physik, 170: 162-4(1962). (In German)

The photoproton spectrum from $C^{12}$, irradiated with 31 Mev bremsstrahlung, was measured with an average resolution of 130 kev using a solid state detector. No essential difference to spectra obtained with other methods was found. (auth)

**11750** HIGHER ORDER AVERAGES OF PRIMARY RECOIL DISTRIBUTIONS. G. Leibfried (Oak Ridge National Lab., Tenn.). Z. Physik, 171: 1-18(1963). (In English)

The averages over the distribution of final positions of an energetic primary knock-on in its own lattice were studied. Analytical expression for linear and quadratic averages were given previously. Another method was developed that is easily extended to higher order averages. Topics covered include: the distribution function, general calculations of the averages, evaluation of the averages, operations $1/(1 - g^{(m)})$ in the hard core approximation, illustration of results for inverse power potentials, and representation of the distribution by the three lowest order averages. (M.C.G.)

**11751** TWENTY-PARAMETER EIGENFUNCTIONS AND ENERGY VALUES OF THE $2^3S$ STATES OF He AND He-LIKE IONS. J. F. Hart and G. Herzberg (Univ. of Western Ontario, London and National Research Council, Ottawa). Z. Physik, 171: 83-9(1963). (In English)

Twenty-parameter calculations of the energies and wave functions of the first excited states $2^3S$ of He, $Li^+$, $Be^{2+}$, $B^{3+}$, $O^{6+}$, $Ne^{8+}$, and $Mg^{10+}$, were carried out using Hylleraas' method. The energy values were corrected for mass polarization. The coefficients of the best wave functions are listed. Similar calculations for the $2^3S$ state of the $H^-$ ion yielded an energy value which cannot be distinguished from the energy of a free H atom. For He and $Li^+$, in addition, forty-parameter calculations were carried out. The results compare well with the recent calculations of Pekeris using a somewhat different method. Even after the inclusion of the relativistic correction, the theoretical energy values deviate slightly from the observed. The differences, $-0.10 \pm 0.05$ $cm^{-1}$ for He and $-1.07 \pm 0.10$ $cm^{-1}$ for $Li^+$, represent observed values of the Lamb shifts in the $2^3S$ states. These values agree within their uncertainties with the values predicted from quantum electrodynamics. (auth)

**11752** COMPOUND NUCLEAR AND DIRECT CONTRIBUTIONS TO NEUTRON POLARIZATION. D. J. Hooton (Victoria Univ. of Wellington, New Zealand). Z. Physik, 171: 226-41(1963). (In English)

The factors which contribute to neutron scattering and polarization are discussed in terms of the lifetimes of the compound states formed with the target nucleus. The limitations of the resonance and statistical theories are pointed out with regard to neutron scattering near 1 Mev. The polarization to be expected from a semi-direct resonance in the presence of an average background of optical scattering was calculated. Attention is drawn to data in which such a phenomenon may occur. (auth)

**11753** THE INFLUENCE OF THE HARD CORE ON THE f-SUM OF NUCLEI. W. Biem (Max Planck-Institut für Physik und Astrophysik, Munich). Z. Physik, 171: 265-72(1963). (In English)

Exchange forces modify the f-sum (f-oscillator strengths) by an additional term $\varepsilon\alpha$. $\varepsilon$ was calculated as a function of the hard core radius c for several types of potentials and for two densities of nuclear matter ($r_0 = 1.1$ and 1.2 f). $\varepsilon$ was found to depend strongly on c. (auth)

**11754** ON THE STATISTICAL THEORY OF NUCLEAR REACTIONS. Albrecht Lindner (Universität, Frankfurt am Main). Z. Physik, 171: 379-402(1963). (In German)

If $(n,\alpha)$ and (n,p) effective cross sections for 14.5-Mev neutrons are calculated according to the statistical theory, the results depend perceptibly on the auxiliary quantity used. The effective cross sections for the formation of intermediate nuclei were calculated by the optical model, and, in the energy level density formula, pair effects and the shell structure were considered. In addition, different Q-values were used. In this way the strong deviation between experimental and theoretical values found by Paul and Clarke could clearly be decreased. (tr-auth)

**11755** THE SPECTRA OF NEUTRONS FROM THE REACTIONS $C^{12}(\gamma,n)C^{11}$ AND $O^{16}(\gamma,n)O^{15}$. H. Fuchs and D. Haag (Universität, Heidelberg). Z. Physik, 171: 403-15(1963). (In German)

The $(\gamma,n)$-reactions on carbon and oxygen were studied using the 30.5-Mev bremsstrahlung beam of the Heidelberg betatron. The photoneutrons were detected via the recoil protons in a stilbene scintillator. The pulse height spectrum of scintillations produced in the stilbene crystal by the recoil protons was analyzed to yield the incident neutron energy distribution. The $\gamma$ and electron background was strongly reduced through pulse shape discrimination. To test the apparatus the spectrum of the neutrons from a Po-$\alpha$-Be source was measured. The energy spectrum of the photoneutrons from $O^{16}$ showed clearly two peaks at excitation energies of 22.4 and 24.4 Mev also seen in the photoproton spectra. The energy distribution of the neutrons from $C^{12}(\gamma,n)$ also contained indication of structure already known from the proton spectra from $C^{12}(\gamma,p)$. The derived cross sections of $C^{12}(\gamma,n_0)$ and $O^{16}(\gamma,n_0)$ coincided as well in their shape as in their absolute magnitude with the corresponding $(\gamma,p_0)$-cross sections. In both $C^{12}(\gamma,n)$ and $O^{16}(\gamma,n)$-reaction the neutrons seem to leave the final nucleus mainly in its ground state. (auth)

**11756** THE SPECTRA OF PHOTONEUTRONS FROM $O^{18}$ AND $N^{14}$. H. Fuchs (Universität, Heidelberg). Z. Physik, 171: 416-23(1963). (In German)

Water enriched to 97% in $O^{18}$ and liquid nitrogen were irradiated with 30.5 Mev bremsstrahlung. The energy distribution of emitted neutrons between 2.5 and 20 Mev was measured via the recoil protons in a stilbene scintillator. The energy spectrum of photoneutrons from $N^{14}$ showed maxima at 3.0, 6.5, and 11 Mev, whereas that of neutrons from $O^{18}$ contained only indication of structure. For both nuclei emission of neutrons seemed to proceed mainly through transitions into excited levels of the final nuclei. (auth)

**11757** CHARACTERISTIC ENERGY LOSSES IN THE SCATTERING OF MEDIUM-FAST ELECTRONS ON ALUMINUM SURFACES. Juergen Lohff (Universität, Hamburg). Z. Physik, 171: 442-8(1963). (In German)

The energy distributions of electrons scattered by variously treated (111) surfaces of aluminum crystals and their dependence on scattering angle was measured by an electrostatic analyzer with a spherical condenser. Etched surfaces showed, in the diffraction maxima, discrete energy losses with intensities similar to those of thin aluminum foils. Electrolytically polished surfaces ($H_3PO_4$ + $CrO_3$ bath) showed no diffraction patterns of Al, and the energy distribution was that of aluminum oxide. After removal of the oxide film, the diffraction pattern of even surfaces appeared. In the diffraction maxima, the intensity of the energy loss of 6.7 ev was high; the intensity of the energy loss of 14.9 ev increased with increasing order of the diffraction maxima. The angular distributions of the intensities of the discrete energy losses near the diffraction spots were similar to those observed at thin foils and agreed with theory. (auth)

**11758** AN EXPANSION OF THE SIEGERT THEOREM FOR $\beta$ TRANSITIONS. Joerg Eichler (Universität, Heidelberg). Z. Physik, 171: 463-75(1963). (In German)

Assuming the validity of the conserved vector current hypothesis the Siegert theorem for electromagnetic transitions was extended to vector transitions in beta decay. The starting point was an appropriate definition of the current density by means of the nuclear Lagrangian. The current has three components in isospace. The third component (which is responsible for electromagnetic transitions) is conserved strictly but the other two (which are responsible for beta decay) have a finite divergence caused by electromagnetic interactions. The explicit form of the divergence in terms of the Lagrangian leads to an estimate which apart from small corrections is independent of nuclear structure. This expression was used to obtain approximate relations between matrix elements containing the current density and matrix elements containing charge distributions only. After elimination of the former matrix elements the number of free parameters entering into the analysis of beta decay experiments was reduced. Experiments seemed to indicate the validity of the predicted relations between matrix elements. (auth)

**11759** THE ELECTRIC QUADRUPOLE MOMENT OF THE 14.4-kev LEVEL OF $Fe^{57}$. H. Eicher (Technische Hochschule, Munich). Z. Physik, 171: 582-9(1963). (In German)

The temperature dependence of electric field gradients in iron fluosilicates was calculated when the spin-orbit coupling of the 3d electrons was considered. The intensity of the trigonal crystal field components, which are determined by the temperature behavior of the field gradients, were suited to the magnetic properties of the crystal. Variations from earlier works were obtained. The quadrupole moment of the 14.4-kev level of $Fe^{57}$ was calculated to be $+0.15 \pm 0.01$ b. This value must still be corrected with reference to the internal Sternheimer effect. (tr-auth)

**11760** EEN METING VAN DE DRACHT VAN URAAN-235. (Charge Measurement of Uranium-235). Gerard Jan Van der Maas. Thesis, Amsterdam, Vrije Universiteit te Amsterdam, 1958. 68p.

The mean charge of the $\alpha$ particles from $U^{235}$ was measured using the Wytzes method. The ionization chamber used was described. The distribution of the residual charge in the ionization chamber was first determined. The relation between the residual charge and the oscillographic results are analyzed. The transposition of the residual charge distribution into a distribution of oscillographic results was made. The calculations are then applied to the case of $U^{235}$. (J.S.R.)

## Particle Accelerators

**11761** (BNL-767) HIGH ENERGY ACCELERATOR PAPERS FROM USSR, PREPARED FOR PRESENTATION AT 1961 INTERNATIONAL CONFERENCE. (Brookhaven National Lab., Upton, N. Y.). Oct. 1, 1962. Contract [AT(30-2)-Gen-16]. 296p.

Twenty-five papers are presented. Separate abstracts are included for nineteen papers; six papers were previously abstracted in NSA. (D.C.W.)

**11762** (BNL-767(p.1-31)) REVIEW OF THE RESULTS OF MAGNETIC MEASUREMENTS AND OF THE METHODS OF MAGNETIC FIELD CORRECTIONS IN A STRONG-FOCUSING 7 Bev ACCELERATOR. L. L. Goldin and V. V. Vladimirskii (Vladimirskij).

Design and parameters of magnets used in a strong-focusing 7-Bev accelerator are discussed, and the electrical compensating systems used to control the beam, particularly oscillations, are described. Magnetic measurements made at the factory, with the magnets in the accelerator ring, and under normal pulsing conditions are reviewed. Comparison of the magnetic properties of the different bending magnets is also presented. Placement of the magnets in the ring and use of ohmic resistances shunted across the spare magnet windings provide correction of variations in the remanent field. Comparison of the magnetic properties of the bending magnets with large gradients and the magnetic lenses with zero field at the orbit, variation of the n-value with magnetization, variation of the magnetic field between pulses, location of the neutral beam in bending magnets, and control by means of betatron oscillations are other aspects treated. Diagrams of apparatus and graphs of various properties are included. (D.C.W.)

**11763** (BNL-767(p.32-47)) THE ELECTRONIC SYSTEMS FOR THE 7 Bev STRONG FOCUSING PROTON SYNCHROTRON. G. I. Batskikh (Batskich), A. A. Vasil'ev, F. A. Vodop'yanov, B. H. Gutner, A. A. Kuzmin, V. F. Kuzmin, Y[u]. M. Lebedev-Krasin, S. M. Rubchinskii (Rubchinskij), and V. A. Uvarov.

Parameters of the first Soviet strong-focusing proton synchrotron to be constructed such that transition energy is eliminated are given, and electronic systems are discussed. Use of ten drift tubes fed by automatically tuned output amplifiers of h-f oscillators yields an energy gain of 4.5 kev/turn. Either a precision programed system or corrections based on data on radial and phase position of the center of gravity of the accelerating bunches are used to synchronize the accelerating field frequency with the revolution frequency. Methods for measuring phase and radial position and other parameters are described, and the ability of the injection and acceleration control system to provide a large number of pulses is noted. (D.C.W.)

**11764** (BNL-767(p.48-63)) THE DESIGN OF THE AUTOMATIC CONTROL SYSTEM FOR THE RADIAL AND PHASE POSITION OF A BEAM IN THE PROTON SYNCHROTRON. E. L. Burshtein (Burstein), F. A. Vadop'yanov, Yu. (U.) S. Ivanov, and A. A. Kuzmin.

Design of an automatic control system for stabilizing the phase and radial positions of the proton beam is discussed. Equations for motion at the center of the beam and feedback circuit characteristics are taking into account a system that operates by corrections on the frequency of the accelerating voltage. Calculations based on this method are made for the 7-Bev accelerator. (D.C.W.)

**11765** (BNL-767(p.64-6)) PARAMETERS OF 50-70 Bev PROTON SYNCHROTRON. V. V. Vladimirskii (Validimirskij).

Selection of parameters for the proton synchrotron to provide a beam energy of 50 Bev and subsequently by 70 Bev, after more experience with transition energy considerations, is briefly discussed, and parameters are listed. (D.C.W.)

**11766** (BNL-767(p.67-74)) FUNDAMENTAL TECHNICAL CHARACTERISTICS OF 4-6 Bev ELECTRON SYNCHROTRON. A. G. Alekseev (Alekseiev), M. A. Gashev, G. K. Gustov, et al.

Parameters for a 4-6 Bev electron accelerator being built for the Armenian S.S.R. Academy of Sciences are listed; and features of various accelerator components such as the electromagnet, power distribution system, injection system, accelerating system, vacuum system, and synchronization system are described. (D.C.W.)

**11767** (BNL-767(p.75-83)) DESIGN CONSIDERATIONS FOR A 500 Bev PROTON SYNCHROTRON. V. V. Vladimirskii (Vladimirskij), L. L. Goldin, D. G. Koshkarev, and E. K. Tarasov.

Considerations involved in designing a 500-Bev proton synchrotron are discussed. A very high injection energy is deemed necessary to keep down chamber dimensions and magnet sizes, and a 15-Bev proton synchrotron is considered as the injector. Proposed parameters for the main accelerator and for the injector synchrotron are listed, as are tolerances permissible in various parameters. (D.C.W.)

**11768** (BNL-767(p.84-90)) TWO-STAGE 300 Bev PROTON CIRCULAR ACCELERATOR WITH STRONG FOCUSING AND COMPENSATION FOR DISTORTION OF THE FOUNDATIONS (PRELIMINARY CONSIDERATIONS). N. I. Dojnikov, N. (H.) A. Monoszon, and I. A. Shukejlo.

A two-stage synchro-phasotron is proposed for the acceleration of protons to hundreds of Bev. Protons accelerated in a small inner ring would go into a larger concentric ring for final acceleration. Main parameters for a two-stage 300-Bev proton circular accelerator with strong focusing are listed along with tolerances and perturbations of particle positions in space. Compensation for perturbations in the second-stage magnetic field due to foundation distortions receives particular attention. (D.C.W.)

**11769** (BNL-767(p.91-9)) CYCLICAL ACCELERATORS FOR HIGH ENERGIES WITH SELF-ADJUSTING MAGNETIC FIELD. E. L. Burshtein, A. A. Vasil'ev, A. L. Mints (Mintz), V. A. Petukhov, and S. M. Rubchinskii (Rubchinskij).

Increases in energies of accelerators are, at present, dependent upon regulation of the characteristics of the magnetic field. Possible systems for regulating the equilibrium orbit and for stabilizing the number of betatron oscillations are examined, and calculations of the parameters of a 300-Bev and a 1000-Bev accelerator are reported. (D.C.W.)

**11770** (BNL-767(p.100-5)) COHERENT ELECTRON RADIATION IN A SYNCHROTRON. Yu. M. Ado and V. V. Elyan.

Coherent electron radiation in a synchrotron is investigated for different distributions within the stability boundary. The method and apparatus used are discussed, and it is noted that the theory of coherent radiation in a synchrotron agrees in only a few specific cases with experimental results. The radiation used is at a wavelength of 10 cm, corresponding to the 50th harmonic of electron revolution frequency for which radiation theory generally applies. (D.C.W.)

**11771** (BNL-767(p.106-15)) ACCELERATION OF ELECTRONS IN A PLASMA. A. M. Stephanovski.

Data taken at the Institute of Nuclear Physics are analyzed to gain insight into the processes of electron acceleration in a plasma. Description of the apparatus is provided, and the results are discussed. Particular attention is given to high amplitude plasma oscillations that appear to hinder electron acceleration. Maximum sharpness of the front of the electric field, fastest possible unifrom distribution of the external electric field, and an external electric field stronger than the fields of plasma inhomogeneities appear to be necessary for successful acceleration of electrons. (D.C.W.)

**11772** (BNL-767(p.134-44)) GENERALIZATION OF REGENERATIVE DEFLECTOR THEORY TO A PHASOTRON WITH AZIMUTHAL VARIATION OF MAGNETIC FIELD. D. M. Kaminker and Yu. Ya. (J. J.) Lembra.

Nonlinear regenerative deflector theory is generalized to beam extraction from a phasotron with an azimuthal variation of magnetic field. Equations for betatron oscillations of a particle subject to and independent of the action of a regenerator are presented, and computations of vertical and radial betatron oscillations are made using a generalized matrix method. Aspects of sector phasotron theory are discussed, and the application of regenerative deflectors in sector phasotrons is considered. (D.C.W.)

**11773** (BNL-767(p.145-60)) ANALOG COMPUTER FOR STUDYING THE MOTION OF PARTICLES IN A PROTON SYNCHROTRON. N. L. Sossenskii (Sossenskij).

Effects of imperfections in computing element characteristics on solutions of problems are considered in designing an analog computer for studying the motion of particles in ring accelerators. Calculations taking into account several such sources of error are made, and the allowable errors for various computer components are determined from the results. Computers meeting these requirements have performed successfully and a block diagram of one is included. (D.C.W.)

**11774** (BNL-767(p.161-71)) PHASE LOCKED OSCILLATOR ANALOG FOR STUDYING PHASE MOTION OF PARTICLES IN A PROTON SYNCHROTRON. A. A. Vasil'ev.

Principles of operation of an electronic analog that makes use of the analog between the phase position of an accelerated particle and the phase of a synchronized frequency-modulated oscillator to serve as a substitute for an accelerator in tests of its electronic systems are considered. An example of a test of the beam control system for the 7-Bev proton synchrotron, using the phase-locked oscillator analog, is presented. (D.C.W.)

**11775** (BNL-767(p.172-6)) POSSIBILITY OF EXECUTING AN EXPERIMENT WITH COLLIDING BEAMS WITH-

OUT STORAGE. V. V. Vladimirskii (Vladimirskij) and D. G. Koshkarev.

Considerations involved in the use of an installation similar to a proton synchrotron for investigations on colliding proton beams are examined. Longitudinal and transverse reduction of the size of proton bunches to increase density is found necessary, but such an installation will be cheaper than a storage-ring synchrotron. (D.C.W.)

**11776** (BNL-767(p.181-97)) THE "SYMMETRICAL" RING PHASOTRON OF THE LEBEDEV INSTITUTE OF PHYSICS. A. A. Kolomenskii (Kolomenskij), V. N. Kanunnikov, E. P. Ovchinnikov, and B. N. Yablokov.

A symmetrical, two-way, ring phasotron that operates by accelerating beams in opposite directions and having them collide has been constructed. Details of the electromagnet are described, and the two means of acceleration to be used (induction and resonance regime) are briefly considered. Comments on the injection system and vacuum chamber are included, and the program for the device is reported. (D.C.W.)

**11777** (BNL-767(p.224-53)) ION SOURCES WITH PLASMA CONTRACTION BY INHOMOGENEOUS FIELD. R. A. Demirkhanov, H. Freulich, [Yu.] (U.) V. Kursanov, and T. I. Gutkin.

Emission properties of high intensity sources of protons with double contraction of the discharge are examined. The double electric layer region, discharge contraction by inhomogeneous magnetic field, and control of ion emission current are some aspects discussed. The case of electrons oscillating in the anode plasma is also considered, and a proton current of several amperes may be reached in this arrangement. Data and diagrams are included. (D.C.W.)

**11778** (BNL-767(p.254-77)) EXPERIMENTS ON ACCELERATION AND EXTRACTION OF IONS IN A CYCLOTRON WITH AZIMUTHALLY VARYING MAGNETIC FIELD AND REGULATED ENERGY. A. A. Arzumanov, R. A. Meshcherov (Metshcherov), E. S. Mironov, L. M. Nemenov, S. N. Rybin (Ribin), and Yu. (J.) A. Kholmovskii (Kholmovskij).

Ion acceleration and extraction in a cyclotron with azimuthally varying field and regulated energy is investigated. Apparatus and method used in experiments are described. Successful acceleration and extraction of 31.5 Mev deuterons at beam currents of about 70 $\mu$a are reported for the 1.5-m cyclotron. Ion energy regulation in the range of magnetic fields 5 to 17 kgauss is also performed, and complete compensation of fringe field defocusing action is used and studied. Energy determination experiments reveal a spread of $\pm 1\%$ at all energies. (D.C.W.)

**11779** (BNL-767(p.278-87)) DECREASE OF ION BUNCH DURATION AND RECURRENCE FREQUENCY OF BUNCH IN A CYCLOTRON. N. I. Venikov.

Improvement of the resolution of the fast neutron spectrometer in time-of-flight dictates a decrease of pulse-duration. Limitation of starting phase range and choice of acceleration modes are examined as means for producing the decrease. Changing the frequency of ions by deflection is also investigated since the frequency of the ion bunch needs to be decreased to improve the spectrometer's range to low energies. Deflection of ions at final energy is found advisable, and various data are shown. (D.C.W.)

**11780** (BNL-767(p.288-92)) IMPROVEMENT OF ION BEAM ENERGY SPREAD AT THE CYCLOTRON OF THE ATOMIC ENERGY INSTITUTE. N. I. Venikov and N. I. Chumakov.

The use of diaphragms with slits on the dees and with ion source shifted along the dee edges from the center of the magnet to reduce particle energy spread in cyclotron beams is examined. The parameters of ion beams for three modes of acceleration with such diaphragms are compared with parameters of a mode of deuteron acceleration without diaphragms. (D.C.W.)

**11781** (BNL-6189) A COMPUTER PROGRAM TO OPTIMIZE MAGNETS IN A BEAM TRANSPORT SYSTEM. Winslow F. Baker (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT-30-2-GEN-16]. 5p.

A program that examines the emergent beam and varies the parameters of the beam transport system to optimize the beam has been written for the IBM 704 and 7090 computers. Maximizing the merit function is given particular attention, and the merit functions in the program are shown. (D.C.W.)

**11782** (BNL-6645) SOME FURTHER REMARKS ON BEAM CURRENT MEASUREMENTS IN THE AGS. Internal Report. E. C. Raka (Brookhaven National Lab., Upton, N. Y.). July 30, 1962. Contract [AT(30-2)-Gen-16]. 16]. 14p.

Comparison of measurements made on the injected beam current of the Brookhaven AGS by current transformer and wire calibrated electrode measurements show that previously quoted measurements based on wire calibration have been as much as 15% too high. Future measurements and the current transformer method are also discussed. (D.C.W.)

**11783** (BNL-6670) THE DEFLECTING MODE IN THE CIRCULAR IRIS-LOADED WAVEGUIDE OF A RF PARTICLE SEPARATOR. Internal Report. H. Hahn (Brookhaven National Lab., Upton, N. Y.). Oct. 25, 1962. Contract [AT(30-2)-Gen-16]. 23p.

An analysis is presented of the deflecting mode in an iris-loaded synchrotron waveguide which is not based on the concept of TE and TM modes as generating fields. The solutions employed are derived from the transverse components of the electric and magnetic Hertzian factors. Their use avoids the singularities in the field expressions for phase velocities equal to that of light, which must occur with TE and TM modes. The fundamental properties of the hybrid solutions are exposed. The lowest mode of the hybrid group is the desired deflecting mode. The exact relation between frequency, phase velocity, and geometry of the structure can be derived for the deflecting mode in the form of an infinite determinant. Transverse and hybrid solutions are tabulated. (J.R.D.)

**11784** (BNL-6673) ACCELERATION OF DEUTERONS OR ALPHA PARTICLES IN THE AGS. Internal Report. E. D. Courant (Brookhaven National Lab., Upton, N. Y.). Dec. 18, 1962. Contract [AT(30-2)-Gen-16]. 14p.

Possible experiments that could be performed at the Brookhaven alternating gradient synchrotron using high-energy deuterons and heavier nuclei are reviewed. Particular attention is given to production of high-energy neutrons by stripping. A brief analysis of changes needed to accelerate heavier nuclei reveals such modifications would not be prohibitive. (D.C.W.)

**11785** (BNL-6678) STUDIES OF THE RAPID BEAM EJECTOR AT THE COSMOTRON. M. Q. Barton (Brookhaven National Lab., Upton, N. Y.); W. Kernan, T. Novey, S. Warshaw (Argonne National Lab., Ill.); and A. Wattenberg (Illinois. Univ., Urbana). Jan. 16, 1963. Contract AT(30-2)-Gen-16. 14p.

Extraction of the external beam of the cosmotron with

maximum efficiency and minimum duration for measurements of the magnetic moment of the lambda hyperon requires addition of a rapid beam ejector (RBE). Early experiments with the RBE give lower ejection efficiency than the standard ejection system. Reconstruction of the RBE with lengthening of the rise time of the system gives improved values. Computer studies that involve solving the equation of motion for the radial betatron oscillation with time increasing perturbation in one section yield information on particle distributions and result in increases of the turn spacings in RBE to prevent betatron oscillation distribution distortions. Ejection efficiency is now the same with and without the RBE. (D.C.W.)

**11786** (CTSL-36) A STUDY OF THE SECOND-DIFFERENCE METHOD FOR RADIAL MAGNET ALIGNMENT. Jon Mathews (California Inst. of Tech., Pasadena. Synchrotron Lab.). Nov. 27, 1962. Contract AT (11-1)-68. 10p.

Preliminary estimates indicate that the cost of surveying the main ring of the proposed 300 Bev cascade synchrotron will be quite high, because of the large diameter and small tolerances. A scheme has been suggested in which the only measurements to be made are local, relating each magnet to its neighbors. The principal difficulty with the method lies in the accumulation of errors from the large number of observations. A model scheme of this type is considered in some detail. (W.D.M.)

**11787** (LNF-62/96) NON LINEAR EFFECTS ON THE DAMPING CONSTANTS OF ELECTRON OSCILLATIONS IN A SYNCHROTRON. Note No. 166. C. Pellegrini (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). Nov. 21, 1962. 5p.

Following up Hereward's demonstration that the nonlinearity of the expression for radiated energy can be important in strong-focusing accelerators, perhaps to avoid antidamping on the radial betatron oscillation mode, the synchrotron damping constant is re-evaluated considering the nonlinear terms to be in the expression for radiated energy. A formula that agrees well with Hereward's is derived. (D.C.W.)

**11788** (MATT-119) THE EFFECT OF A FINITE ION GYRATION RADIUS ON THE STABILITY OF THE STELLARATOR. Russell M. Kulsrud (Princeton Univ., N. J. Plasma Physics Lab.). May 1962. Contract AT(30-1)-1238. 71p.

The stability of the stellarator type equilibria is calculated from the combined Maxwell and Vlasov equations in the limit of small gyration radii but taking into account first order terms in the ion gyration radius. It is shown that for all such equilibria the first order ion gyration radius terms make the equilibria more stable than one would think from the results of the zero order theory. The equilibria treated may be defined as essentially all those in the neighborhood of the cylindrical equilibrium with zero pressure and axial magnetic field. The results of the gyration radius correction are given. Application of this result is made to the case of a trefoil helical equilibrium, and it is shown that in some cases appreciable gain in stability is obtained from the ion gyration radius correction. (auth)

**11789** (NYO-10251) DESIGN OF A QUADRUPOLE CHANNEL. Stephen V. Pepper (Rochester, N. Y. Univ.). Dec. 4, 1962. Contract AT(30-1)-875. 10p.

The calculation of design parameters of a quadrupole channel to contain an external particle accelerator beam is considered on the basis of the matrix method of calculating betatron oscillation amplitudes. The principal result is a relation between the physical parameters of the magnets and the acceptance solid angle of the system relative to the beam source. (auth)

**11790** (PPAD-459F) THEORY AND METHODS OF MAGNET SYSTEMS DESIGN (thesis). Jacob Y. M. Wong (Princeton–Pennsylvania Accelerator, Princeton, N. J.). May 1, 1962. Contract AT(30-1)-2137. 121p.

Submitted to Princeton Univ., N. J.

Magnetic devices for transporting a secondary beam of charged particles of specific momentum or magnetic rigidity from one spatial position to another was investigated. These devices were generally magnetic quadrupole lenses and bending magnets. Basic components of purely magnetic systems, techniques of tracing particle trajectory using matrices, beam transport calculations by the phase ellipse method, combinations of basic components of magnetic systems, aberrations, magnet system design, and a triple-focusing system are described. (M.C.G.)

**11791** (RT/EL(62)14) STUDIO DI UN DISCRIMINATORE DI FASE PER L'ACCORDO DEI RISUONATORI A CAVITÀ IMPIEGATI NELLE MACCHINE ACCELERATRICI. (Study of a Phase Discriminator for Tuning of Cavity Resonator Employed in Accelerators). A. Massarotti and M. Puglisi (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). June 1962. 14p.

A very simple and practical phase detector designed for the automatic tuning of the very high power cavity resonator employed in the orbital particle accelerator is described. Extremely large band width of the detector is noted, and many theoretical and experimental results are shown. (auth)

**11792** (RT/EL(62)15) EFFETTO DEL CARICO ELETTRONICO SULLE CAVITÀ RISONANTI DELLE MACCHINE ACCELERATRICI ORBITALI. (Effect of Electronic Loading on the Resonant Cavity of Orbital Accelerating Machines). M. Puglisi (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). Sept. 1962. 33p.

The type of radiofrequency plant typical of orbital accelerating machines is demonstrated, and formulas are given that show that the accelerating device (resonant cavity) is loaded by the beam and that the loading depends only on the characteristics of the beam and the accelerating voltage. Design criteria for the power amplifier-resonant cavity ensemble are given as a function of the characteristics of the beam to be accelerated. Two actual cases are developed to show the conclusions obtained. (auth)

**11793** (SLAC-2) DISCUSSION OF FOCUSING REQUIREMENTS FOR THE STANFORD TWO-MILE ACCELERATOR. R. H. Helm (Stanford Univ., Calif. Stanford Linear Accelerator Center). Aug. 1962. Contract AT (04-3)-400. 38p.

As part of a discussion on focusing requirements of the Stanford two-mile accelerator, treatment is given the transmission of an electron beam showing that for reduction of beam size a number of lenses are required. Some strong-focusing arrangements are discussed, and a section on choice of parameters such as quadrupole strength, length of unfocused machine, number of quadrupoles, and quadrupole spacing is included. A numerical example dealing with a positron beam is given, and design characteristics of a few quadrupoles are listed. (D.C.W.)

**11794** (SLAC-3) SHOWER DEVELOPMENT AND HEATING IN THE WAVEGUIDE STRUCTURE WITH AN 800 Mev ELECTRON BEAM. J. K. Cobb and J. J. Muray (Stanford Univ., Calif. Stanford Linear Accelerator Center). July 1962. Contract AT(04-3)-400. 37p.

A temperature measurement along the axis of the Mark

III accelerator to get information on the heat conduction properties of the waveguide and on axial and radial shower development is made using a section of disk-loaded copper accelerator structure two feet long with ten probe-type thermistors inserted into the first ten disks. Three other thermistors are fastened to the outside of the waveguide section. Diagrams and graphs of temperature rise vs time and temperature rise vs heating power are given for the thermistors. Data on the heating of the accelerator section by the 800-Mev beam are also examined. (D.C.W.)

**11795** (SLAC-4) ADIABATIC APPROXIMATION FOR DYNAMICS OF A PARTICLE IN THE FIELD OF A TAPERED SOLENOID. R. H. Helm (Stanford Univ., Calif. Stanford Linear Accelerator Center). Aug. 1962. Contract AT(04-3)-400. 19p.

Theory for beam guidance devices having a longitudinal magnetic field that varies slowly in the longitudinal direction is generally based on the assumption that particles have no angular momentum. More general theory that allows finite angular momenta is developed. The equations of motion are integrated in the adiabatic approximation, and the results are given in terms of a transfer matrix from the initial to the final transverse dynamical coordinates. Validity conditions for the approximation are examined, and an adiabatic invariant function of the transverse dynamical coordinates is developed. This function is useful in problems involving phase-space transformations and in matching and predicting the transmission of the system. (D.C.W.)

**11796** (SLAC-6) THE PRINCIPLE OF DESIGN OF MAGNETIC MOMENTUM SLITS. E. L. Chu and J. Ballam (Stanford Univ., Calif. Stanford Linear Accelerator Center). Oct. 1962. Contract AT(04-3)-400. 39p.

The magnetic field in the central region of a momentum slit may be expanded into a series of either regular or irregular $2\ell$-poles, $\ell$ being even integers $\geq 2$. For regular $2\ell$-poles, $\ell = 2\nu$; for irregular $2\ell$-poles, $\ell = 2\nu$. The first few multipoles are the dominant terms. To design an effective momentum slit it is necessary to eliminate several lower-order terms. From pure symmetry arguments it was shown that in the case of slit systems having no iron cores the first three terms ($\ell = 2$, 4, and 6) may be eliminated, and that in the case of iron slit systems at least the first two terms may be eliminated. An example is given illustrating how the aperture field in an air-core slit system can be made small by using simple corrective systems of surface currents. The return conductors of the corrective systems are supposed to be far removed from the axis of symmetry. By neglecting the effects of these return conductors, the field distribution inside the slit opening was calculated. The maximum field in the region $\rho \lesssim a$ is only about $3.6 \times 10^{-3}$ of the maximum field $\mu_0 I$ outside this region. If $\mu_0 I$ is taken to be 10 kilogauss, then $I \approx 8{,}000$ amp/cm and the current in the corrective current sheets is of the same order of magnitude as I. This current is too large to be actually used, unless the current is pulsed with a duty cycle of about 0.002 or smaller. It is also possible to use superconducting current sheets. If iron cores are used and the maximum gap field is again 10 kilogauss, the main exciting current is smaller, reduced by a factor of about $\mu_0/\mu$. The corrective currents, however, remain of the same order of magnitude as 8,000 amp/cm. Current sheets are used for simplifying calculations. If the slit system is not sufficiently long in the z-direction, the end effects may become important. Detailed calculations for designing iron momentum slits are presented. Two integral equations were derived. (auth)

**11797** (TID-16967) THE CEA SYSTEM FOR MEASUREMENT OF ELECTRON BEAM INTENSITY AND POSITION. L. Holcomb, D. Porat, and K. Robinson (Cambridge Electron Accelerator, Mass.). June 15, 1962. Contract AT(30-1)-1909. 26p. (CEA-89(MH))

Pick-up coils for the measurement of charged particle beam intensity and position, are described. Design considerations are discussed and results are presented for the system used in the 6 Bev Cambridge Electron Accelerator. A procedure for correcting orbit distortions based on the information derived from the pick-up coils is shown. (auth)

**11798** (TID-17221) LINEAR ELECTRON ACCELERATOR STUDIES. Status Report, January 1 to March 31, 1958. (Stanford Univ., Calif. Microwave Lab.). Apr. 1958. Contract AT(04-2)-21. 46p. (ML-504).

Lines of work being followed in the Mark IV accelerator program are briefly reviewed. Performance of various elements such as the double window and titanium pump assembly, the spark gap, and the ten-foot electroformed accelerator section at Mark II is discussed. New accelerator structures being investigated are disk-loaded waveguides and grid-loaded structures. New fabrication techniques for r-f couplers and metal vacuum seals at waveguide joints are mentioned as is a method for joining electroformed accelerator sections. Beam-loading studies, beam analysis instrumentation, klystron improvement studies, photographic and ionization chamber dosimetry work, and the use of phosphors to observe beam shape are other topics discussed. Reports on a new operational master oscillator and a gun tester are also included. Various diagrams and curves are displayed. (D.C.W.)

**11799** (TID-17617) THE EFFECT OF DISSOCIATION ON THE UPPER ENERGY LIMIT OF NEGATIVE HYDROGEN IONS IN ISOCHRONOUS CYCLOTRONS. Tat K. Khoe (Argonne National Lab., Ill.). Sept. 18, 1962. Contract [W-31-109-eng-38]. 20p. (ANLAD-72)

An elementary derivation of the dissociation constant, i.e., the dissociation probability per second, is given. The formula obtained is used to evaluate the particle losses due to dissociation in synchrocyclotrons and in isochronous cyclotrons. For the latter, two extreme cases are considered: a square-wave field and a sinusoidal field variation. The results are given as plots of particle losses against energy. The dependence of the energy limitation in the maximum magnetic field is also evaluated. (auth)

**11800** (TID-17642) ZGS EXTERNAL PROTON BEAM STUDIES. L. G. Ratner (Argonne National Lab., Ill.). Sept. 26, 1962. Contract [W-31-109-eng-38]. 18p.

Doubts about the beam size originally calculated for the Argonne ZGS led to a study of the entire system, particularly the Piccioni extraction system. A revised method for estimating the residual betatron amplitude after the Piccioni target lip is used, and results indicate the beam size can be improved. (D.C.W.)

**11801** (TID-17652) FAST EJECTION OF PROTON BEAMS FROM A SYNCHROTRON BY A PULSED MAGNET AND AN ENERGY-LOSS TARGET. S. Suwa and A. Yokosawa (Argonne National Lab., Ill.). Oct. 9, 1962. Contract [W-31-109-eng-38]. 29p. (ANLAD-73)

As a fast ejection device for a weak-focusing proton synchrotron, the use of a pulsed magnet and an energy-loss target has been investigated. This method is suitable for producing the beam pulses of down to 10 μsec with high efficiency. The emittance of the ejecting beam of the horizontal plane can be made significantly smaller than that of the circulating internal beam, as long as the major part of

the radial width of the internal beam comes from the betatron oscillation. Numerical calculations are made to find the optimum arrangement for the ZGS. (auth)

**11802** (TID-17661) ON MIRROR-SYMMETRY IN BEAM TRANSPORT SYSTEMS. Cyril H. M. Turner (Argonne National Lab., Ill.). Sept. 28, 1962. Contract [W-31-109-eng-38]. 18p.

Algebraic expressions for the matrices representing some mirror-symmetric beam transport systems in terms of the elements of an initial transfer matrix representing the building block for the system are given. Interpretation of zeros in the chromatic elements of general $3 \times 3$ transfer matrices for an overall system as well as synthesis of such a system from mirror-symmetric arrangements of building blocks is discussed. Illustrative tables are provided. (D.C.W.)

**11803** (TID-17691) PROPOSAL FOR A 4 Bev/c UNSEPARATED ANTIPROTON BEAM FOR COUNTER EXPERIMENTS. S. M. Marcowitz and L. G. Ratner (Argonne National Lab., Ill.). Oct. 17, 1962. Contract [W-31-109-eng-38]. 4p.

Design, layout, and characteristics of the 4 Bev/c unseparated antiproton beam to be provided at the ANL zero gradient synchrotron are shown and discussed. (D.C.W.)

**11804** (TID-17693) MAGNETIC MEASUREMENTS OF BENDING MAGNET BM-102. Robert J. Lari (Argonne National Lab., Ill.). Oct. 22, 1962. Contract [W-31-109-eng-38]. 22p.

Description, characteristics, and testing of the bending magnet BM-102 are reported. Graphs and tables display leakage fields with and without use of correction coils, effect of correction coil on central field, and determination of the magnet's operating field in addition to various other information. (D.C.W.)

**11805** (TID-17728) LINEAR ACCELERATOR PROJECT PROGRESS REPORT, OCTOBER 1962 THRU DECEMBER 1962. (Rensselaer Polytechnic Inst., Troy, N. Y.). Contract AT(30-3)-328. 17p.

Measurements on water are expected to yield high precision decay constants for large values of buckling. Measurements of asymptotic spectra in polyethylene are also being made, and the Linac is being used in experiments with multiplying media. Neutron capture cross sections and neutron resonances in iron isotopes 54, 56, and 57 and hafnium isotopes 176, 177, 178, 179, and 180, as well as tungsten-184, are reported. Polarization of neutrons from the reaction d(γ,n) is examined, and neutron thermalization by matrix eigenvalue techniques is being studied. Improvements in the RAMP System of codes for thermal neutron studies are explained. (D.C.W.)

**11806** (TID-17735) THE UNIVERSITY OF MICHIGAN 83-INCH CYCLOTRON. Progress Report No. 10, October 1, 1962–December 31, 1962. W. C. Parkinson and R. S. Tickle (Michigan. Univ., Ann Arbor. Coll. of Literature, Science, and the Arts). Jan. 1963. Contract AT(11-1)-921. 12p. (ORA-03763-10-P)

Preliminary tests indicate that the University of Michigan 83-inch spiral-ridge cyclotron will operate satisfactorily as designed and that no difficulty will be met in obtaining low energy proton and deuteron beams out to extraction radius. The tests and resultant corrections on the cyclotron are described, and field measurements on the focusing magnets are reported. (D.C.W.)

**11807** (TID-17829) A STUDY OF DEFLECTION METHODS FOR 50 Mev PROTON BEAM. J. F. Mech and S. W. Zimmerman (Argonne National Lab., Ill.). Sept. 25, 1962. Contract [W-31-109-eng-38]. 38p.

Considerations involved in designing a switching magnet for a 50-Mev proton beam are discussed, and sample calculations for a switching magnet are presented. Methods to obtain the necessary rapid flux change are explored and include electrostatic means, electromagnetic arrangements electromechanical systems, hybrid systems, subdivision of the magnetic field, and translational and rotational devices. The various arrangements are illustrated and discussed, and a table of their characteristics is included. (D.C.W.)

**11808** (UCRL-10081) GENERAL DESCRIPTION AND OPERATING CHARACTERISTICS OF THE BERKELEY 88-INCH CYCLOTRON. Elmer L. Kelly (California. Univ., Berkeley. Lawrence Radiation Lab.). Apr. 26, 1962. Contract W-7405-eng-48. 23p.

Design characteristics, and testing of the Berkeley 88-inch cyclotron are discussed. The machine accelerates protons to 50 Mev, deuterons to 60 Mev, and heavier ions to corresponding energies. Internal-beam studies with alphas at 60 Mev show a well-behaved beam out to full radius. Diagrams of the layout are accompanied by graphs displaying test data. (D.C.W.)

**11809** (UCRL-10163) MEASUREMENT OF RADIATION FIELD AROUND HIGH-ENERGY ACCELERATORS. Alan R. Smith (California. Univ., Berkeley. Lawrence Radiation Lab.). Apr. 1962. Contract W-7405-eng-48. 14p.

Measurement of the radiation field (particularly fast neutron flux) around the 6.3 Bev Bevatron at Berkeley, evaluation of health hazards presented, and design of shielding to reduce radiation are discussed. The instrumentation is described as well as its use with pulsed accelerators, and results with the Berkeley accelerator are presented. (D.C.W.)

**11810** (USASRDL-TR-2257) CAPTURE OF ELECTRONS INTO STABLE BETATRON ORBITS. George J. Brucker (Army Signal Research and Development Lab., Fort Monmouth, N. J.). Jan. 1962. 22p. (AD-277706)

Conditions were established for electron capture in the radial well associated with a rising magnetic field that has a vector potential. Equations of motion are presented, and the use of an electron gun to inject a pulse of electrons into the field from a position outside the well region is examined. Such injection is found to be possible with a judicious choice of injection voltage. Examination of angular momentum considerations reveals that the limiting value of angular momentum is $5 \times 10^{-4}$, be it positive or negative. (D.C.W.)

**11811** (NP-tr-932) AUTOMATIC CLOSED ORBIT CONTROL. A. A. Vasil'ev (Vasil'jev) and N. I. Kuz'mina (Akademiya Nauk S.S.R. Radiotekhnicheskii Institut). Translated by E. Fischer. 1961. 15p.

A fast operating system for automatic control of the position of the closed orbit of a circulating beam is studied. Equations for a closed orbit with perturbations are examined, and ways of designing a computer to handle the necessary mathematics are explored. Block diagrams of the control system are included. (D.C.W.)

**11812** ELECTRON IRRADIATION FACILITY AT THE DANISH ATOMIC ENERGY COMMISSION RESEARCH ESTABLISHMENT, RISÖ. Ari Brynjolfsson. Ingeniøren, 6: 101-4(Oct. 1962). (In English)

The electron accelerator irradiation facility at Risø, Denmark, used for industrial sterilization of medical sup-

plies, research in reactor technology, study of the effect of irradiation on bacteria, and food irradiation research is described. Energy and dose calibration of the facility are explained, and a few dose distributions are displayed. (D.C.W.)

**11813** METHODS FOR VARYING THE INTERACTION TIME BETWEEN THE BEAM AND TARGET IN THE 10-Bev SYNCHROPHASATRON. G. S. Kazahskii, A. I. Mikhailov, K. P. Myznikov, and A. P. Tsarenko (Joint Inst. for Nuclear Research, Dubna, USSR). Pribory i Tekhn. Eksperim., No. 5, 19-24(Sept.-Oct. 1962). (In Russian)

Methods for changing the beam frequency and pulse duration in a 10-Bev synchrophasatron are suggested in order to carry out several experiments during a single acceleration cycle. Resonance phase oscillation buildup, reduction of acceleration amplitude, reduction of radial beam dimensions during acceleration, instant change of acceleration phase intensity, and changes in acceleration frequencies are described. (R.V.J.)

**11814** LINEAR ION BUNCHING DEVICE. O. I. Kozinets, F. L. Shapiro, and I. V. Shtranikh (Inst. of Physics, Academy of Sciences, USSR). Pribory i Tekhn. Eksperim., No. 5, 25-8(Sept.-Oct. 1962). (In Russian)

Bunching ions at the peak intensity of a pulse arriving at a constant rate $V_f$, and height corresponding to the relative ion motion were studied. The monoenergetic beam remains monoenergetic after the bunching. Multiple beam compression by subsequently distributed bunching systems was also analyzed. (tr-auth)

**11815** POLARIZATION STUDIES OF LOW ENERGY CHARGED PARTICLES. B. V. Gavrilovskii and K. V. Karadzkev (Inst. of Nuclear Energy, Academy of Sciences, USSR). Pribory i Tekhn. Eksperim., No. 5, 28-32(Sept.-Oct. 1962). (In Russian)

The design is given of a device for studying double interactions of low-energy charged particles. The vacuum chambers, working with electrostatic generators, and other described auxiliary equipment are well adapted to various polarization experiments. An example is given of proton polarization in elastic scattering on $Ne^{20}$, measured with 1.4 mg/cm$^2$ carbon foil. The 1990 kev protons, after scattering at 60°, enter a neon-filled chamber at 100 mm mercury pressure. The particles scattered at 80° are recorded by ~0.2 mm thick and $\phi$22 mm CsI crystal placed at ~70 mm from the center. Nearly 300 protons/min were recorded on the carbon target at a current ~2 $\mu$a. (R.V.J.)

**11816** THE EFFECT OF INJECTOR FOCUSING ON GAMMA EMISSION INTENSITY IN A BETATRON. V. N. Logunov and S. S. Semenov (Inst. of Physics, Academy of Sciences, USSR). Pribory i Tekhn. Eksperim., No. 5, 35-7 (Sept.-Oct. 1962). (In Russian)

The $\gamma$ intensity was measured as a function of injector focusing. The experiment employed a 30-Mev synchrotron with betatron acceleration and an injector with a beam angle regulated by a diaphragm lens. (tr-auth)

**11817** INVESTIGATION OF TARGET PERFORMANCE TEMPERATURE. V. I. Petrov and E. M. Oparin. Pribory i Tekhn. Eksperim., No. 5, 38-40(Sept.-Oct. 1962). (In Russian)

The thermal behavior of Zr targets, saturated with tritium or deuterium, on a copper backing was studied. A 200-kw acceleration tube with up to 3 $\mu$a proton currents was used for measuring the beam density on the target and the temperatures near the zirconium layer and on the cooled surface. (tr-auth)

**11818** CONTROL OF CYCLOTRONS OPERATING WITH MULTIPLY CHARGED IONS. G. Indreas and V. Oganesyan (Joint Inst. of Nuclear Research, Dubna, USSR). Rev. Phys., Acad. Rep. Populaire Roumaine, 7: 25-7(1962). (In Russian)

Acceleration of heavy ions in 120-cm cyclotrons working with heavy particles (deuteron and $\alpha$ particles) has been discussed previously. It was shown that small alterations could create favorable conditions for accelerating elements with mass-charge ratios $2 < (A/Z) < 3.7$ and energies up to ~5 Mev per nucleon. An attempt was made to use DH (10% abundant in ordinary technical deuterium). The molecule $DH^+$ can be easily separated by target bombardment into a deuteron and a proton with identical velocities ($E_d = 2E_p$). The deuteron energy is equal to $E_d = (2/3)E_{(DH)}$. The results showed certain practical advantages in the use of DH in cyclotron operations. (R.V.J.)

**11819** DYNAMIC METHOD FOR STUDYING RESONATOR CAVITIES WITH HIGH Q FACTOR. I. Teodoresku. Rev. Phys., Acad. Rep. Populaire Roumaine, 7: 45-51 (1962). (In Russian)

Electron accelerators with resonance cavities producing millimeter waves are studied. Accelerated electrons pass axially through a cylindrical resonator with $TM_{010}$ type oscillations. Resonator excitations up to 1 to 2 Mev are supplied by a pulsed magnetron through a rectangular waveguide connected with the cavity by an annular opening. The operations demand as high a resonator Q factor as possible and a high waveguide coordination. An assembly is suggested for instrumenting the resonator cavities without distorting the true parameters. (R.V.J.)

**11820** THE "ADA" ACCUMULATOR RING FOR 250-Mev ELECTRONS AND POSITRONS. C. Bernardini, U. Bizzarri, G. Corazza, G. Di Giugno, G. Ghigo, R. Querzoli, and B. Touschek (Università, Rome and Comitato Nazionale per l'Energia Nucleare, Frascati, Italy). Ric. Sci., Riv., 2: 137-44(June 1962). (In Italian)

The theory and principles of accumulator rings are given as an introduction to the description of the design and performance of the AdA accumulation ring. (J.S.R.)

**11821** INVESTIGATIONS ON THE PRODUCTION OF X-RAY BREMSSTRAHLUNG IN A BETATRON. Gert Harigel, Helmut Haeufgloeckner, Eberhard Keil, Max Scheer, and Juergen Severlein (Universität, Wurzburg, Ger.). Z. Angew. Phys., 14: 585-95(Oct. 1962). (In German)

The processes in the production of x-ray bremsstrahlung at the internal anticathode of the Wurzburger 35-Mev betatron can be extensively clarified by various experimental and theoretical research methods. By the use of simple thin and thick anticathodes forced conditions are present in the electron motion that prevent a homogeneous penetration of the anticathodes by the accelerated electron. It was shown that by utilization of complicated anticathodes for the production of x-ray bremsstrahlung definite conditions could be created. A simple method was described with which conclusions on the type and number of multiple passages of electrons through anticathodes could be obtained from the half-value width of the angular distribution of the x-ray bremsstrahlung. (tr-auth)

**11822** APPLICATION OF AN INCIDENT MODULATION OF PARAMETERS IN CYCLE ACCELERATORS AND SIMILAR SYSTEMS. A. A. Kolomenskii and A. N. Lebedev (Lebedev Inst. of Physics, Moscow). Zh. Tekhn. Fiz., 32: 1237-44(Oct. 1962). (In Russian)

Uniform particle motion in periodic systems (strong-focusing cyclic accelerators), where the particle parameters undergo small fluctuations with time, was investigated. These fluctuations result in considerable slowing

down of betatron oscillation resonance rate and in the appearance of a certain stochastic oscillation buildup. Formulas were derived for determining the influence of parameter fluctuations and for evaluating the feasibility of utilizing them for reducing harmful resonance effects. (tr-auth)

**11823** A MODEL OF CYLINDER IRON-FREE BETATRON WITH AXIAL MAGNETIC FOCUSING. Yu. S. Korobochko and K. S. Shilkov (Leningrad Polytechnic Inst.). Zh. Tekhn. Fiz., 32: 1245-7(Oct. 1962). (In Russian)

An iron-free betatron with axial focusing achieved by additional magnetic lenses installed at the tips of the acceleration area, an equilibrium orbit radius of 40 mm, and external selenoid current density 1 v/cm is described. The betatron is 157 mm in diameter and 600 mm long; the coil is 600 mm long and 40 mm in (mean, double winding) diameter. Internal selenoid current is 5 v/cm. Acceleration capacity is ~150 kw. (R.V.J.)

**11824** A METHOD OF ACCELERATING ELECTRONS IN AN INDUCTION ACCELERATOR. Bohumir Šusta. Czechoslovak Patent 97,206. Nov. 15, 1960.

A proposal is made to replace the accelerating chamber in a betatron-type induction accelerator with injector by a ring made of a material that can be brought to a superconducting state (Sn–Bi alloy). If such a ring, cooled down to a necessary temperature, is placed into the betatron magnet gap, a flux of accelerated conductivity electrons can be produced with a density exceeding several times that obtained in the conventional betatron. To generate gamma radiation, it is proposed to use an electrode specially welded to the superconducting ring; material of the electrode should preserve conductivity close to the normal one (tungsten). Displacement of the equilibrium orbit is performed in the usual way. (Referativnyy Zhurnal, Fiyika, No. 5, 1962).

**11825** A METHOD FOR THE OUTLET OF PARTICLES IN A CYCLIC ACCELERATOR. Friedrich Schubert. German Patent 21,852. Aug. 21, 1961.

A schematic design of a device for displacing electrons from an equilibrium orbit in a betatron is proposed. The device can be utilized when the betatron is provided with so-called stabilizing windings, one of which is located within the equilibrium orbit, and the second (divided into the upper and lower part) is outside this orbit, and both windings are connected in parallel. At a definite phase of betatron magnetic cycle the circuit of stabilizing windings is broken (by means of a rotation synchronous switch), and the capacitor is discharged through both coils. As a result, electrons are displaced from the equilibrium orbit; depending on the polarity of voltage in the capacitor it is possible to displace electrons either inwards or outwards relative to the orbit. The capacitor is charged with voltage induced in the stabilizing winding. For this purpose, a rectifier or the second synchronous switch is used. (Referativnyy Zhurnal, Fiyika, No. 5, 1962).

## Plasma Physics and Thermonuclear Processes

**11826** (AD-273961) RESEARCH STUDIES OF HIGH-DENSITY PLASMAS. First Quarterly Progress Report, September 15, 1961 to December 15, 1961. Report No. 1. E. Bialecke, L. Dreyer, D. Albares, L. Slama, and L. Goldstein (Illinois. Univ. Urbana. Engineering Experiment Station). Contract DA 36-039-SC-87232. 25p.

The fabrication of the apparatus required for the formation of a high density plasma is in progress. The instrumentation for the investigation of the properties of high density plasmas was partially tested. For the formation of the high density plasma, a bank of capacitors is discharged through a one turn coil. Measurements of the magnetic field strength, uniformity and variation in time were made. Testing of microwave equipment is proceeding and indicates that there is greater than 2% ionization in the plasma. Photomultiplier observations of the visible light emitted by the plasma did not show satisfactory agreement between any two photomultiplier tubes. Spectroscopic investigations are also in progress. A laser is under construction for use as a diagnostic tool in very high density plasmas. (auth)

**11827** (AD-277601) THEORETICAL INVESTIGATIONS AND DESIGN STUDIES FOR THE EVENTUAL CONSTRUCTION OF A MEASURING DEVICE IN THE FIELD OF PLASMA ELECTRONICS. PART III. CALCULATION OF THE DEFLECTION OF A PLANE ELECTROMAGNETIC WAVE PENETRATING A CYLINDRICAL PLASMA COLUMN. Final Report, May 1, 1961–February 28, 1962. (Battelle Institut e. V., Frankfurt am Main). June 15, 1962. Contract DA-91-591-EUC-1018). 53p.

The deflection of a bundle of parallel rays penetrating a cylindrical plasma column with parabolic electron density distribution is examined. The phase transit time of a ray in the plasma column can be determined under special assumptions. The following cases are studied: At first it is assumed that rays penetrate the plasma near the symmetry axis of the arrangement and that, owing to small electron density, these rays are only slightly deflected. The phase transit time of rays penetrating the plasma undeflected was determined; in this case the amount of calculations required is substantially smaller than in the first case. The accuracy of this result can be improved by assuming V-shaped rays instead of direct rays. An even more exact result can be obtained by consideration of the local dependence of the refraction index in the plasma cylinuer. The functions resulting from the numerical calculations are shown graphically. (auth)

**11828** (AFCRL-62-63) PLASMA CONFINEMENT OF ELECTROMAGNETIC WAVES. Scientific Report No. 16. G. August (California. Univ., Berkeley. Electronics Research Lab.). Aug. 24, 1961. Contract AF19(604)-2270. 145p. (AD-277373)

The wave propagation, wave confinement, and r-f power loss characteristics of certain plasma waveguides were studied theoretically. Plasma-guides having a cross section consisting of a circular vacuum region surrounded by plasma were studied in finite, zero, and infinite d-c axial magnetic fields. A formal solution was obtained for the finite field case. Quantitative solutions were obtained for certain of the other cases. Plasmaguide propagation characteristics normally closely resemble those of metal circular waveguide. The plasmaguide skin depth is about the velocity of light divided by the radian plasma frequency. When multiple Coulomb collisions of the plasma particles are the dominant r-f power loss mechanism, the plasmaguide has a Q exceeding that of a metal circular waveguide for plasma electron energies in excess of several ev, for typical microwave operating conditions. (auth)

**11829** (ASD-TR-61-179(Vol.I)) STUDY OF NOISE PROPERTIES OF GAS DISCHARGES. VOLUME I. A. Van Der Ziel (Minnesota. Univ., Minneapolis). Apr. 1961. Contract AF33(616)-5479. 22p. (AD-267978)

The study of electromagnetic radiation from gaseous plasma gives information about the basic interaction processes responsible for this type of radiation, and can serve as a tool to measure the average energy over electrons

present in a plasma. For a Maxwellian energy distribution, this gives the temperature of the electrons, which is an important quantity in plasma physics. The results obtained indicate that reliable data can be obtained, provided sufficient care is taken in eliminating systematical errors. The measurements are carried out in the frequency range 100 to 2000 Mc/s and concern the transition of a plasma from a transparent to an opaque condition, the frequency spectrum of the plasma radiation, and comparison of results with the data obtained with conventional Langmuir probes. (auth)

**11830** (D1-82-0166) THE MAGNETOGASDYNAMIC SOURCE. Report No. 58. F. D. Hains (Boeing Scientific Research Labs., Seattle). May 1962. 22p. (AD-278073)

A study is made of magnetogasdynamic source flow with crossed electric and magnetic fields. The uniform electric field is normal to the plane of the source, and the magnetic field lines are concentric circles about the center of the source. The analysis is restricted to small magnetic Reynolds numbers and assumes the electrical conductivity is constant. Three different cases are considered. If the electric field vanishes, the flow is isoenergetic, and all solutions choke except one which starts from the maximum velocity at a point near the center of the source, and decelerates through the sonic velocity to stagnation conditions at infinity. If the magnetic field vanishes, all solutions choke. For the general case when both the magnetic and electric fields are acting, a solution is obtained in which the flow accelerates at constant Mach number and pressure. At the center of the source the velocity and temperature must be zero. As the flow accelerates, the velocity increases linearly with distance, while the temperature increases with the square of the distance. (auth)

**11831** (LAMS-2816) QUARTERLY STATUS REPORT OF THE LASL CONTROLLED THERMONUCLEAR RESEARCH PROGRAM FOR PERIOD ENDING NOVEMBER 20, 1962. (Los Alamos Scientific Lab., N. Mex.). Dec. 1962. Contract W-7405-eng-36. 17p.

Progress is reported on controlled thermonuclear research. Topics covered include: Picket Fence IIB, Picket Fence III, plasma gun and diagnostics, coaxial gun investigation, large-bore hydromagnetic gun research, development of coaxial gun for injection into magnetic fields, Scylla I x rays, Scylla I zeeman experiment, Scylla IV, and capacitor and equipment development. (M.C.G.)

**11832** (MATT-106) ON A NEW METHOD IN THE THEORY OF IRREVERSIBLE PROCESSES. Edward A. Frieman (Princeton Univ., N. J. Plasma Physics Lab.). Nov. 1, 1961. Contract AT(30-1)-1238. 28p.

A new method is presented for obtaining irreversible equations describing the approach to equilibrium in systems of many particles. The basic idea is the removal of secular terms arising in a perturbation expansion by the technique used in nonlinear mechanics. The irreversible equations then appear as consistency conditions for the existence of a well behaved expansion. The method relies heavily on the existence of the natural fine scale mixing occurring in the dynamics. Application of the theory to a classical, weakly coupled system is made, with both spatially homogeneous and inhomogeneous cases being treated. (D.C.W.)

**11833** (MATT-114) AN EVALUATION OF KADOMTSEV'S THEORY OF PLASMA TURBULENCE. Arthur F. Kuckes (Princeton Univ., N. J. Plasma Physics Lab.). Mar. 1962. Contract AT(30-1)-1238. 27p.

An explanation of the stellarator pumpout phenomenon via turbulence generated by a convective resistive instability is proposed. This theory is examined critically and found to be too slow to fit the experiments by more than an order of magnitude. (auth)

**11834** (NP-12367) NATIONAL AERONAUTICS AND SPACE ADMINISTRATION SEMIANNUAL STATUS REPORT NO. 4, MAY 1,–OCTOBER 31, 1961. (Rensselaer Polytechnic Inst., Troy, N. Y.). Nov. 1961. 17p.

An improved method of measuring the transformation tensor, which represents the effect of the magnetoplasma on an electromagnetic wave, was devised. A logical foundation for plasma theory was developed. The waveguide plasma cell was used to investigate the He afterglow. The effect of a cataphoresis pump on gas purity was investigated by spectrographic measurements. The scope of the Cherenkov radiation experiment was broadened to include analysis of the production of longitudinal plasma waves by the bunched relativistic electron beam. Such waves are detected as electromagnetic radiation if conditions for their transformation are fulfilled. Improvements were made in the pulsed radiometer for measurement of electron temperature in afterglow plasmas. The Cu discs for the magnetic field coil were machined and soldered together. Bussing for the battery bank was completed and a battery charging system installed. A design for the measurement and plotting of the magnetic field using a Hall effect device was completed. (auth)

**11835** (ORNL-3387) DCX-2 PERFORMANCE CURVES. M. Rankin and T. K. Fowler (Oak Ridge National Lab., Tenn.). Jan. 28, 1963. Contract W-7405-eng-26. 20p.

Performance curves of steady state ion density versus injected currents for a survey of various parameters are given. The parameters are $E_M$, the energy of injected $H_2^+$ ions; L, the ion path length; and factors h and $\Gamma$, where $h/\Gamma$ is the fraction of the undissociated portion of the molecular beam not absorbed and $\Gamma$ is taken as 2. Performance curves are also computed assuming the energy transfer rates to be enhanced by arbitrary factors of 10 and 100. (auth)

**11836** (RADC-TDR-62-186) ENERGY TRANSFER IN PLASMA. Final Report. J. E. Hopson and J. Kannelaud (General Telephone and Electronics Labs., Inc., Palo Alto). Mar. 26, 1962. Contract AF30(602)-2452. 66p. (AD-278098)

Results of investigations are presented concerning diagnostic techniques for determining plasma shock wave characteristics and molecular-related absorption of microwave energy by plasma. Work done in the program on the reflectivity and absorptivity in inhomogeneous plasma is reported separately. In shock tube work, plasma shock densities of $10^{14}$ electrons/cc were created in shock fronts traveling at 1 to $5 \times 10^3$ m/sec in low-pressure He. In microwave absorption research, the ortho He metastable populations in microwave-excited He discharges were measured along with plasma density and electron collision frequency. (J.R.D.)

**11837** (TID-16215) RF OSCILLATIONS AND POWER OUTPUT IN ALKALINE THERMIONIC CONVERTERS. H. K. Richards (Argonne National Lab., Ill.). Apr. 1962. Contract W-31-109-eng-38. 18p. (UAC-6389)

Experiments were made using a potassium plasma cell with a Ta emitter and a Ag-plated Cu collector. The r-f frequencies, rms voltages, power output, and other quantities were measured under various conditions of emitter temperature, potassium vapor pressure, and d-c and r-f loads. Ion and electron densities were calculated and compared with the oscillations occurring. (D.L.C.)

**11838** (TID-16990) STUDIES OF PLASMA OSCILLATIONS. Quarterly Status Report No. 10, March 1–May 31, 1962. (Stanford Univ., Calif. Microwave Lab.). Sept. 1962. Contract AT(04-3)-326. 11p. (ML-950)

The possibility that low-frequency oscillations in a plasma may be generated in the cathode sheath is being investigated. An ion-electron diode was constructed and tested. A computer program for integrating the system of equations, which form the basis of the theoretical approach to the problem, was written. Results indicated that the design used to build a cesium electron-ion diode according to the Langmuir model was unsuccessful. (M.C.G.)

**11839** (UCRL-10366) ELECTRON-ENERGY DISTRIBUTIONS AND IONIZATION RATES IN HYDROGEN WITH CROSSED ELECTRIC AND STRONG MAGNETIC FIELDS. Gary A. Pearson and Wulf B. Kunkel (California. Univ., Berkeley. Lawrence Radiation Lab.). Sept. 5, 1962. Contract W-7405-eng-48. 62p.

The calculation of the electron velocity distribution in a slightly ionized gas with $(\omega_b\tau)^2 \gg 1$ is discussed, including a detailed treatment of inelastic processes. The derived equations apply whenever the gas density $n_g$, the gas-flow velocity, $\vec{E}$, and $\vec{B}$ are spacially uniform and constant in time, the component of $\vec{E}$ parallel to $\vec{B}$ is negligible, and E is much less than B (in Gaussian units). The equations are suitable for numerical computation of the electron energy distribution and drift velocity in the reference frame in which $\vec{E}$ is negligible and the gas flow is perpendicular to $\vec{B}$ so that the electron velocity distribution is nearly isotropic. When the rms molecular speed in this frame is much smaller than the rms electron speed, the equations can be greatly simplified. With simplified equations, the electron-energy distribution, drift velocity, ionization rate, and diffusion tensor in cold stationary $H_2$ gas are calculated for cE/B between $4 \times 10^6$ and $6 \times 10^7$ cm/sec. Whereas the electron-energy distribution depends only on cE/B, the other quantities also have simple dependence upon $n_g$ and $\omega_b$. In view of the large uncertainty in important collision cross sections, the agreement with recent experimental results is considered reasonably good. (auth)

**11840** (AEC-tr-5612) PRESENT STATUS OF THE IBIC (ION BEAM INJECTION AND CYCLOTRON HEATING) EXPERIMENT. Translated for Oak Ridge National Lab., Tenn., from Kaku Yugo Kenkyu, 9: 351-77(Oct. 1962). 34p.

The machine built to examine ion trapping by injection into a Miller's type d-c magnetic field and subsequent cyclotron resonance heating is described, and various components are discussed. Microwave and Faraday cup measurements are described that indicate that ions are trapped, but an r-f discharge due to the low vacuum prevents further elevation of the ion temperature. A higher vacuum system is to be constructed. Formation of a high density plasma beam from the arc-type low energy-high current ion source used in the present layout is of particular note. (D.C.W.)

**11841** (AEC-tr-5620) STUDY OF THE LOSS OF PLASMA THROUGH A MAGNETIC APERTURE OF TRAPS WITH A FIELD INCREASING TOWARD THE PERIPHERY. L. O. Gorelik, N. G. Koval'skii, I. M. Podgornyi, and V. V. Sinitsyn. Translated by Helen J. Chick and John E. Osher (Los Alamos Scientific Lab., N. Mex.). 1962. 12p.

The effect of the region near the null point of the magnetic field on the loss of charged particles from a magnetic trap with the field increasing toward the periphery is investigated using the "Orekh" trap that can provide quadrupole and octapole field shapes. Equipment used is discussed briefly, and experiments show that the width of the magnetic aperture is greater at small magnetic field values. Different mechanisms seem to account for particle losses in the two configurations. (D.C.W.)

**11842** HEAT AND MOMENTUM TRANSFER IN LAMINAR FLOW: HELIUM INITIALLY AT PLASMA TEMPERATURES. R. J. Wethern and Robert S. Brodkey (Ohio State Univ., Columbus). A.I.Ch.E. (Am. Inst. Chem. Engrs.). J., 9: 49-54(Jan. 1963).

A study was made of the laminar flow of monatomic gases. It was found that the Graetz type of correlation holds sufficiently well for prediction of heat transfer coefficients for the gases. Equations are given for a complete analysis of the various sources of error, an approximate and rapid means of estimating the friction factor, and an approximate but rapid means of estimating the heat transfer coefficient. It appears that the temperature estimation is by far the major source of error, because of insufficiently accurate voltage and current measurements and questions concerning the heat loss term. (P.C.H.)

**11843** WAVE PROPAGATION IN A CYLINDRICAL WAVE GUIDE CONTAINING INHOMOGENEOUS PLASMA INVOLVING A TURNING POINT. S. N. Samaddar (Raytheon Co., Wayland, Mass.). Can. J. Phys., 41: 113-31 (Jan. 1963).

Propagation of axially symmetric E-type and H-type modes of electromagnetic waves in a radially inhomogeneous plasma inside a wave guide is considered. For E-type modes conditions for the propagation of slow surface waves along the plasma-dielectric interface have been obtained. Approximate expressions for fields for wavelengths much smaller than the ratio of the gradient of the permittivity to the permittivity of the plasma are also given. It is also shown that if the dielectric constant $\epsilon(r)$ of the plasma vanishes along a particular surface $r = r_0$, the electromagnetic fields for E-type modes behave singularly along this surface. In particular, if $\epsilon(r)$ has a simple zero at $r_0 \neq 0$, the radial and the longitudinal electric fields become singular as $1/\epsilon(r_0)$ and $\log \epsilon(r_0)$ respectively at $r_0$. On the other hand, if $\epsilon(r)$ has a multiple zero at $r_0$, the singularities of the above-mentioned fields will be as strong as a multiple pole at $r_0$. Turning-point phenomena are also observed when the radial wave number $\eta_1'(r)$ vanishes along a surface. It is shown that the fields are oscillatory in the region $\eta_1'^2(r) > 0$ and evanescent in the region $\eta_1'^2(r) < 0$ for both E-type and H-type modes. The treatment of the singular behavior of the fields at $\epsilon(r) = 0$, and of the turning-point phenomena at $\eta_1'^2(r) = 0$, does not consider any boundary effect; therefore the results obtained here will be valid also for an inhomogeneous plasma column in free space. (auth)

**11844** THE STATIC POTENTIAL ATTAINED BY AN INFINITE CYLINDER IMMERSED IN A MOVING AND LOW DENSITY PLASMA OF INFINITE EXTENT. Dipak L. Sengupta (Univ. of Michigan, Ann Arbor). Can. J. Phys., 41: 132-42(Jan. 1963).

The static potential acquired by an infinite cylinder immersed in a low density collisionless plasma is discussed in detail. It is assumed that the plasma is uniform at large distances from the cylinder and of infinite extent and has a constant drift velocity in one specific direction. Approximate expressions for the distribution functions of the electrons and ions in the presence of the conducting cylinder are derived from the collisionless Boltzmann equation. An expression for the static potential of the cylinder is derived from the condition that the electrical neutrality of the plasma is maintained at large distances

from the cylinder. Simplified expressions for the static potential are given for various physical situations. The case of stationary plasma is obtained as a special case of the former when the drift velocity equals zero. Numerical values are given for some cases. (auth)

**11845** CONFIGURATIONS OF HIGH FREQUENCY ELECTROMAGNETIC FIELDS AND ASSOCIATED MAGNETOSTATIC FIELD WITH RESPECT TO THE CONFINEMENT OF A PLASMA. Jacques Pottier (Centre d'Études Nucléaires, Saclay, France). Compt. Rend., 255: 2066-8 (Oct. 22, 1962). (In French)

The frequency of the electromagnetic field confining a plasma can be reduced if a static magnetic field is used conjointly. The conditions that should satisfy such combinations are briefly examined, and some solutions are proposed. (tr-auth)

**11846** Z PINCH WITH RESPECT TO THE MECHANISM OF THERMAL ENERGY CONCENTRATION. J. G. Linhart. Ind. At., 6: No. 9-10, 69-78(1962). (In French)

Four types of linear Z pinch are compared for their capacity for the production of a high thermal energy in a plasma. It is shown that a thin cylindrical plasma layer pushed adiabatically toward its symmetrical axis gives the highest energy concentration. (tr-auth)

**11847** LOW-FREQUENCY STABILITY OF NONUNIFORM PLASMAS. Nicholas A. Krall and Marshall N. Rosenbluth (General Atomic Division, General Dynamics Corp., San Diego, Calif.). Phys. Fluids, 6: 254-65(Feb. 1963).

A collisionless plasma in equilibrium with a slightly nonuniform magnetic field is studied to determine its stability against growing low-frequency oscillations whose propagation vector is perpendicular to the magnetic field. The method employs the collisionless Boltzmann equation and Maxwell's equations to obtain the eigenfrequencies of the oscillations. Previous work on this problem was based on a longitudinal approximation, i.e., the oscillation was assumed to have electric vector parallel to its direction of propagation. The present work does not make this approximation and finds: (i) a mode which corresponds to the mode found in longitudinal approximation, with the same eigenvalue as given by that approximation; (ii) modes with polarization similar to the "longitudinal" mode which are purely oscillatory; (iii) a purely transverse mode which is unstable. These results are compared with magnetohydrodynamic and other approximations. (auth)

**11848** NONLINEAR EFFECTS FROM VLASOV'S EQUATION. F. Engelmann, M. Feix, E. Minardi, and J. Oxenius (Euratom, Brussels). Phys. Fluids, 6: 266-75(Feb. 1963).

Nonlinear effects from Vlasov's equation are studied for a one-dimensional electron gas with fixed neutralizing background. The electron distribution function is expanded in Hermite polynomials and a closure condition is introduced to cut off the resulting infinite system of differential equations for the expansion coefficients. Then a nonlinear partial differential equation can be derived for the electric field. The consequences of some different closure conditions are studied. It turns out that their use implies severe restrictions on the physical situations described. In the discussed closed polynomial approximations no nonlinear instabilities are found. In particular, it results that with vanishing heat flux one has only stable linear or nonlinear oscillations showing that unstable situations are necessarily nonadiabatic. In an analogous manner, the condition that the plasma follows a state law with pressure proportional to density, like a perfect gas, eliminates unstable modes. (auth)

**11849** CYCLOTRON RADIATION FROM A HOT PLASMA. W. E. Drummond and M. N. Rosenbluth (General Atomic Division, General Dynamics Corp., San Diego, Calif.). Phys. Fluids, 6: 276-83(Feb. 1963). (GA-2644)

The angular dependence of the absorption coefficient of cyclotron radiation is obtained from the Vlasov equation and evaluated numerically, and the total radiation from both slab and cylindrical plasmas is calculated. The critical harmonic $m^*$ (below which the radiation is effectively contained) is presented graphically as a function of $T_e$, and the combination $\beta_e BL/1-R$. The results for the total radiation are in agreement with the earlier results of Trubnikov and Kudryavtsev. The energy production in a thermonuclear reactor is computed for several different models and compared with the cyclotron radiation loss to find the critical size. The critical size depends on $(1/\beta_e)^3$ and the $\beta = \beta_e + \beta_i = 0.40$, the critical size is moderate (less than a meter) for all but the most unfavorable assumptions. For smaller $\beta$ reflectors must be used to obtain reasonable critical sizes. (auth)

**11850** COUPLING OF MAGNETOHYDRODYNAMIC TO ELECTROMAGNETIC WAVES AT A PLASMA DISCONTINUITY. I. RADIATION FIELD. Nazakat Ullah (Allied Research Associates, Inc., Boston) and Sheldon L. Kahalas. Phys. Fluids, 6: 284-9(Feb. 1963).

The coupling of magnetohydrodynamic waves to electromagnetic waves at a plasma-vacuum interface is studied for a general orientation of the external, constant magnetic field and of the direction of the incident wave propagation vector with respect to the normal to the boundary. It is found that there is a cone with its axis along the normal to the boundary within which the incident magnetohydrodynamic wave vector must fall in order that the transmitted electromagnetic wave be radiated, i.e., in order that the Poynting vector be real. The cone has a half-angle of the order of the ratio of the Alfvén velocity to the light velocity, which is very small in most cases. The ratio of the transmitted to the incident Poynting vectors is usually of the order of the ratio: Alfvén velocity/light velocity, but exhibits an anomaly for the extraordinary magnetohydrodynamic wave propagating in a constant magnetic field inclined to the interface. The variation of the individual electric and magnetic fields across the interface is discussed. In some cases, the fields in the vacuum are greatly increased over their values in the plasma. (auth)

**11851** EXCITATION OF ELECTROSTATIC PLASMA OSCILLATIONS NEAR THE ION CYCLOTRON FREQUENCY. R. M. Motley and N. D'Angelo (Princeton Univ., N. J.). Phys. Fluids, 6: 296-9(Feb. 1963).

Oscillations near the ion cyclotron frequency have been excited in thermal cesium and potassium plasmas by drawing current in a filament along the axis of the plasma column. The oscillations appear to be electrostatic waves propagating radially from the filament. The waves are present if the electron drift velocity exceeds about 10 times the ion thermal velocity, in agreement with the prediction of Rosenbluth. The measured phase velocity is also in agreement with the phase velocity calculated from the fluid equations. (auth)

**11852** NOTE ON THE ONE-DIMENSIONAL THEORY OF RADIO-FREQUENCY PLASMA CONFINEMENT. H. Motz (New York Univ., New York). Phys. Fluids, 6: 308-10(Feb. 1963).

A self-consistent solution for the case of a plasma with density lower than critical, confined in a cylindrical cavity resonator, has been found previously by numerical computation. There exists some fault regarding the possibility of

radio-frequency confinement of a plasma above critical density, thus a simple consideration is offered with conclusions that do not seem to have been noticed in the literature on the subject. (W.D.M.)

**11853** SOME RESULTS USING OPTICAL INTERFEROMETRY FOR PLASMA DIAGNOSTICS. Alan K. Klein (Aerospace Corp., El Segundo, Calif.). Phys. Fluids, 6: 310-11(Feb. 1963).

A Mach-Zehnder interferometer is being used to diagnose plasma generated in a conical-driver, electromagnetic shock tube of the Josephson type. The interferometer light source is provided by a 0.005-in. tungsten exploding wire supplied by a 30-$\mu$F capacitor bank charged to 18 kv. Some preliminary interferograms in $H_2$ photographed with a rotating mirror camera to provide time resolution (~0.1$\mu$sec) of the fringe pattern are given. (W.D.M.)

**11854** OBSERVATION OF A SEPARATION OF THE EMISSION LIGHT DURING PLASMA INJECTION. R. G. Tuckfield and F. R. Scott (General Atomic Division, General Dynamics Corp., San Diego, Calif). Phys. Fluids, 6: 311-13 (Feb. 1963). (GA-3373)

In the course of investigating the axial injection of plasma into a cylindrical vacuum magnetic field, it was observed that in the light emission during injection a dark region separated the portion of the plasma having $\beta < 1$ (ratio of plasma to field pressure). The circumstances of observation and several possible explanations for this dark space are reported. (W.D.M.)

**11855** ON IMPURITY RADIATION LOSSES FROM A HOT SPHERICAL PLASMA. S. Cuperman, F. Engelmann, and J. Oxenius (Association EURATOM-CEA sur la Fusion, Fontenay-aux-Roses, France). Phys. Letters, 2: 71-2 (Aug. 15, 1962) (In English)

The specific intensity of the impurity radiation from a hot plasma is determined from the equation of radiative transfer and the steady-state balance for the occupation numbers of the ground and excited levels, using a simplified model. The source function has been solved numerically for various optical thicknesses and excitation strength parameters. Using these results, a formula for the total energy loss of a spherical plasma by impurity radiation is obtained that is accurate to within 10% for both small and large optical thicknesses. (H.D.R.)

**11856** COMPARISON OF EXPERIMENTS WITH THE THEORETICAL SCATTERING BEHAVIOUR OF A COLD PLASMA CYLINDER (OR ANISOTROPIC DIELECTRIC ROD) WITH A MAGNETICALLY INDUCED ANISOTROPY AND INHOMOGENEITY. A. M. Messiaen and P. E. Vandenplas (Ecole Royale Militaire, Brussels). Phys. Letters, 2: 193-6(Sept. 15, 1962). (In English)

The scattering of a plane-polarized electromagnetic wave by a cylinder containing a cold plasma or an anisotropic dielectric rod is studied. The magnetic and Poynting vectors of the incident wave are parallel and perpendicular to the cylinder axis, respectively. A static magnetic field exists that is parallel either to the cylinder axis, the Poynting vector, or the electric vector of the wave. The plasma is described by its equivalent tensorial permittivity, and the Maxwell equations are used. Anisotropic effects resulting from the constant magnetic field are studied in a plasma of constant equilibrium density, and the permittivity tensor is expressed in a form that can be used in the treatment of the dielectric rod. Plasma inhomogeneities induced by the steady magnetic field are taken into account. The theoretical results are compared with experimental data. (T.F.H.)

**11857** ANOMALOUS DIFFUSION IN A PLASMA PERPENDICULAR TO A MAGNETIC FIELD. G. Briffod, M. Gregoire, and C. Manus (Centre d'Etudes Nucléaires, Saclay, France). Phys. Letters, 2: 201-3(Sept. 15, 1962). (In French)

The radial electric field distributions, the high-frequency noise, and the anomalous character of the ion diffusion across a magnetic field in a PIG reflex discharge are studied. Plasma instabilities are found in two regions of the magnetic field. One type of instability is connected with the existence of a high radial electric field, and the origin of the other is less clear as a result of its coincidence with a region of high-frequency noise. The role played by microinstabilities in anomalous diffusion is discussed. (T.F.H.)

**11858** RESONANCES OF A SMALL PLASMA SPHERE IN A MAGNETIC FIELD. Manuel Cardona and Bruce Rosenblum (RCA Labs., Princeton, N. J.). Phys. Rev., 129: 991-7(Feb. 1, 1963).

Resonances of a sphere of plasma in a magnetic field are discussed for a radius small compared to the wavelength of the incident radiation. There are two classes of resonances: radius independent and radius dependent. The former are the electrical analog of the resonant modes originally observed in ferrites by White and Solt. The latter are related to the electromagnetic resonances of a dielectric sphere. Although some of the approximations used in calculating the electromagnetic resonances are not obviously valid, they give remarkably good agreement with experiments on small spheres of indium antimonide. In particular, it is shown that a strong resonance is associated with a mode which is essentially a rotating magnetic dipole. (auth)

**11859** OSCILLATIONS OF A PLASMA IN A MAGNETIC FIELD. M. J. Stephen (Yale Univ., New Haven). Phys. Rev., 129: 997-1004(Feb. 1, 1963).

The plasma oscillations of a high-temperature and a degenerate plasma, both with and without an applied magnetic field, are discussed using a Green function technique. For the high-temperature plasma in lowest order the results reduce to those obtained via the linearized Boltzmann-Vlasov equation in the classical limit. The quantum mechanical effects are important for strong fields where the quantization of the orbits of the electrons in the field must be taken into account. The dispersion relation of a degenerate plasma in a magnetic field is obtained within the random phase approximation. This dispersion relation is discussed for various special cases. The fluctuation spectrum of the plasma is obtained by making use of the fluctuation dissipation theorem. (auth)

**11860** PROFILES OF STARK-BROADENED BALMER LINES IN A HYDROGEN PLASMA. W. L. Wiese, D. R. Paquette, and J. E. Solarski (National Bureau of Standards, Washington, D. C.). Phys. Rev., 129: 1225-32(Feb. 1, 1963).

A stationary hydrogen plasma was generated in a high current stabilized arc and its temperature was determined spectroscopically from the diagnostics of the line and continuum radiation. Extensive measurements of the profiles of the Balmer lines $H_\beta$ and $H_\gamma$ were made and show that recent improvements in the theory of Stark broadening describe the observed line shapes well. Electron densities determined from linewidth measurements are slightly higher than those derived from line intensity measurements. In the covered range of electron densities from $10^{16}-10^{17}$ $cm^{-3}$ and temperatures around $10^4$ °K the difference amounts to about 25% for $H_\gamma$ and 12% for $H_\beta$, for which a refined Stark-broadening theory is available. In addition, the intensity distribution in the distant line wings of $H_\alpha$ and $H_\beta$ was measured and compared with asymptotic formulas. Satisfactory agreement is obtained. (auth)

**11861** CORRECTIONS TO THE DIELECTRIC CONSTANT OF A DEGENERATE ELECTRON GAS. Arnold J. Glick (Univ. of Maryland, College Park). Phys. Rev., 129: 1399-1410(Feb. 1, 1963).

The Lindhard approximation to the frequency- and wave-number dependent dielectric constant, $\epsilon(k,\omega)$, provides a good description of many properties of the degenerate electron gas. However, it is known that the short-range behavior of the gas is not adequately represented by this function and it is necessary to include certain additional terms. DuBois incorporated some exchange terms into $\epsilon(k,\omega)$ and was able to obtain the correction to the plasmon excitation frequency. Though his final results are reasonable and have been corroborated using alternative approaches the "corrected" dielectric constant is found to violate certain a priori restrictions. In this paper a more accurate dielectric constant is derived. In order to obtain an acceptable function which does not violate the sum rule and positive definiteness restrictions on the imaginary part it is necessary to account for three types of corrections. These corrections originate in (1) the effective screening of the long-range interaction between particles; (2) the shift in single-particle energies of electrons and holes; and (3) the tendency of particles and holes to form bound states when any repulsive interparticle interaction is present. With these corrections all spurious singularities in the dielectric constant disappear. Numerical calculations of $\epsilon(k,\omega)$ and of moments of the imaginary part of this function have been carried out for an intermediate electron density equal to the density of conduction electrons in aluminum. The resulting dielectric constant departs by as much as 50% from the Lindhard form for low frequencies, but has similar qualitative features. The moments can be used to determine the high-frequency behavior and other properties of the electron gas. (auth)

**11862** MICROWAVE PROPAGATION THROUGH A PLASMA IN A MAGNETIC FIELD. Derek W. Mahaffey (Boeing Scientific Research Labs., Seattle). Phys. Rev., 129: 1481-8(Feb. 15, 1963).

Experiments have been performed on the propagation of X-band ($\approx 10^{10}$ cps) microwave signals through a plasma in a magnetic field ($\approx$4 kG). The direction of propagation was parallel to the magnetic field lines. The regions of transmission and attenuation for both right-hand and left-hand circularly polarized microwave signals were located, at frequencies above and below both the electron cyclotron frequency and the electron plasma frequency. The range of densities covered was approximately $10^{10}$ electrons/cc to $10^{13}$ electrons/cc. Over part of this range the density measurements were made using an interferometer operating in both the right-hand and left-hand circularly polarized modes. Values of the refractive index greater than and less than unity were measured. Measurements were also made to determine the effect of electron temperature on the electron cyclotron cutoff frequency for the right-hand circularly polarized mode. A downward shift in the cutoff frequency was observed, which is in agreement with the theory. (auth)

**11863** INSTABILITIES IN A PLASMA-BEAM SYSTEM IMMERSED IN A MAGNETIC FIELD. Jacob Neufeld and Harvel Wright (Oak Ridge National Lab., Tenn.). Phys. Rev., 129: 1489-1507(Feb. 15, 1963).

The interaction of an electron or an ion beam moving with velocity $\beta c$ through a stationary plasma in the presence of a static magnetic field is investigated theoretically under the assumption that the plasma is cold, the intensity of the beam is very small, and that the beam, as well as the waves resulting from the interaction, are aligned along the direction of the magnetic field. It is well known that an electron beam moving with velocity exceeding the phase velocity of electromagnetic waves in a stationary plasma is capable of exciting such waves and these waves (circularly polarized) rotate in the same direction and at the same angular frequency as the gyroelectrons of the beam. It is shown in this investigation that there is an apparent reversal in the direction of rotation of these gyroelectrons as seen by the stationary observer. Consequently, the excited wave has a circular motion in the same direction as perturbed stationary ions. The frequency $\bar{\omega}$ of the excited wave satisfies the inequality $|\bar{\omega}| < \Omega_i$, where $\Omega_i$ is the gyrofrequency of perturbed stationary ions. Similarly, a wave excited by an ion beam has a circular motion in the same direction as perturbed stationary electrons. The frequency $\bar{\omega}^1$ of the latter wave satisfies the inequality $|\bar{\omega}^1| < \Omega_e$, where $\Omega_e$ is the gyrofrequency of perturbed stationary electrons. It is shown that an electron (ion) beam moving in the direction of the magnetic field can excite only a wave having negative (positive) helicity. The reverse situation occurs for a beam moving against the magnetic field. General relationships are formulated and illustrated graphically for determining the frequency and growth rate of waves which can be excited by an electron or an ion beam in any magnetized cold plasma. A particular case is illustrated in which an incident ion beam interacts with a relative dense plasma such as occurring in thermonuclear discharges, ionosphere, and interstellar space. It is shown that in such cases there is an excitation of hydromagnetic waves for a wide range of velocities of the ion beam. (auth)

**11864** ABSORPTION OF ELECTROMAGNETIC WAVES IN QUANTUM AND CLASSICAL PLASMAS. Amiram Ron (Princeton Univ., N. J.) and Narkis Tzoar. Phys. Rev. Letters, 10: 45-6(Jan. 15, 1963).

A temperature-dependent Green's function method is used with the Bogoliubov-Born-Green-Kirkwood-Slater-Yvon (BBGKY) hierarchy in a systematic study of electromagnetic-wave absorption and high-frequency conductivity of quantum and classical plasmas. The treatment yields a consistent analysis of multispecies plasmas. (T.F.H.)

**11865** EVIDENCE OF ANOMALOUS RESISTANCE IN PLASMAS. K. I. Thomassen (Stanford Univ., Calif.). Phys. Rev. Letters, 10: 80-1(Feb. 1, 1963).

Observations reported appear to confirm an anomalous resistance in plasmas having electrons drifting through ions with drift energies greater than $\sim$0.9 kT. Investigations were made during the afterglow of an intense plasma (densities $\sim 10^{13}$ cm$^{-3}$) created by a pulsed reflex-type discharge (magnetic field $\sim$200 gauss). The drifts were created by the strong electric fields ($\sim$50 v/cm) in the capacitive region of a 200 Mc/sec re-entrant cavity through which the discharge column penetrated. (C.E.S.)

**11866** NEUTRON PRODUCTION FROM A STEADY-STATE HOT-ELECTRON, DEUTERIUM PLASMA. W. B. Ard, M. C. Becker, R. A. Dandl, H. O. Eason, A. C. England, and R. J. Kerr (Oak Ridge National Lab., Tenn.). Phys. Rev. Letters, 10: 87-9(Feb. 1, 1963).

Neutron emission from the plasma was observed and validated by foil activation measurements. The neutron production rate was optimum when the plasma was adjusted for quiescent steady-state operation. Four methods were used to obtain a rough determination of the energy spectrum of the neutrons. (C.E.S.)

**11867** COULOMB INTERACTION IN A PLASMA WITH ANISOTROPIC TEMPERATURE. Kazuo Kitao (Kyoto Univ.).

Progr. Theoret. Phys. (Kyoto), 28: 105-12(July 1962). (In English)

The Coulomb interaction of a charged test particle with an electron plasma whose unperturbed velocity distribution has different temperatures along and across a certain axis is kinetic-theoretically investigated. In the linear approximation, neglecting the binary correlation, the electric potential and energy loss of a charged test particle and the dielectric constant are derived. By introducing an angular-independent temperature, the dispersion relation and damping constant of plasma oscillations are written in the same form as for the case of an isotropic-temperature plasma. (auth)

**11868** ANOMALOUS PARTICLE LOSS ACROSS A MAGNETIC FIELD IN WEAKLY IONIZED PLASMAS. Yoshi H. Ichikawa and Y. Sasakura (Nihon Univ., Tokyo). Progr. Theoret. Phys. (Kyoto), 28: 210-12(July 1962). (In English)

The possibility of a connection between the Bohm diffusion process and the onset of the helical oscillation instability, which causes enhanced particle losses across magnetic fields in positive columns, is explored. It is concluded that the instability does not initiate Bohm diffusion, but that it does distort the particle distribution in such a way as to increase the radial particle flux. (T.F.H.)

**11869** COULOMB INTERACTION IN A PLASMA IN A UNIFORM MAGNETIC FIELD. Kazuo Kitao (Niigata Univ., Japan). Progr. Theoret. Phys. (Kyoto), 28: 820-8(Nov. 1962). (In English)

The Coulomb interaction in an electron plasma with the different temperatures along and across a constant uniform magnetic field is studied on the basis of the kinetic equation. By neglecting the binary correlation, the polarization potential due to a test particle is derived in a linear approximation and from it the dielectric constant is obtained. It is found that the electrostatic potential is affected by the magnetic field except for the case of the Maxwellian distribution. By using the dielectric constant, the dispersion relation of longitudinal plasma waves is discussed and the conditions of their growth or instability are considered. (auth)

**11870** ON THE MODE-COUPLING DAMPING OF PLASMA OSCILLATIONS. Kenya Matsuura and Kiyoshi Ogawa (Electrotechnical Lab. Nagatacho, Tokyo). Progr. Theoret. Phys., (Kyoto), 28: 946-8(Nov. 1962). (In English)

A report is given on the mode-coupling damping of plasma oscillations due tc plasmon-plasmon interactions which are the nonlinear effects of plasma oscillations. Only an electron plasma is considered. (W.D.M.)

**11871** ON THE CORRELATION OF LOW-FREQUENCY AND HIGH-FREQUENCY OSCILLATIONS EXCITED IN THE PLASMA BY AN ELECTRON BEAM. M. D. Gabovich and V. G. Yazeva. Ukr. Fiz. Zh., 7: 1019-20(Sept. 1962). (In Ukrainian)

The spatial distribution of high-frequency and low-frequency oscillations excited by an electron beam in a plasma is investigated. In the investigated system both types of oscillations always accompany each other, and the spatial distributions of their amplitudes are similar. The observed correlation between the oscillation frequencies and the periodic structure of the spatial distribution of their amplitudes can be explained, if it is assumed that in these experiments ionosonic and electron Langmuir oscillations arise with equal wavelengths. (auth)

**11872** THE STABILITY BEHAVIOR OF A PLASMA TORUS WITH SURFACE CURRENTS. E. Martensen (Max-Planck-Institut für Physik und Astrophysik, Munich). Z. Naturforsch., 17a: 733-62(Sept. 1962). (In German)

The magnetohydrodynamic stability of a toroidal gas discharge is considered by means of a variational principle (energy principle) developed by Bernstein, Frieman, Kruskal and Kulsrud. The plasma is supposed to be surrounded by a vacuum and an external conductor and the electric currents are placed on the plasma-vacuum interface entirely. After some remarks about the mathematical formulation of the problem a rapidly converging numerical method is described, which solves the stability problem for quite arbitrary meridional cross sections of the equilibrium configuration. Examples are given and it turns out that the basic geometry, especially the location assumed for the plasma torus, is very important for the stability. Furthermore there are significant deviations from the well-known behavior of an analogous cylinder configuration. The numerical procedure is verified by comparison of the results in the limit for a very thin torus with the known solution for a plasma cylinder. (auth)

**11873** THEORY OF THE NON-CONTRACTING POSITIVE COLUMN UNDER THE EFFECT OF NEGATIVE IONS. G. Albrecht and G. Ecker (Universität, Bonn). Z. Naturforsch., 17a: 848-53(Oct. 1962). (In German)

A cylindrical positive column of a collision-dominated plasma consisting of electrons, positive and negative ions, and neutral particles is considered. The qualities of such a column are deduced from an eigenvalue problem, which follows from the application of the basic transport equations for such a plasma. The problem presents itself in the form of three simultaneous differential equations with boundary conditions. Applying a procedure from nuclear physics, "Center-Wall-Approximation," three differential equations are reduced to three simultaneous algebraic equations. The numerical evaluation with the help of a digital computer produces the particle densities in the center of the discharge and the electric field as functions of the total current. The results are particularly interesting in the "subnormal" region of the discharge. With increasing current the subnormal decrease of the electric field is first interrupted due to the build-up of the negative ion component which stops the formation of the ambipolar field. The subnormal field decrease continues only at higher currents when the recombination of negative ions and positive ions remove the influence of the negative ion component. Due to these phenomena the subnormal features appear in two steps. The second one is delayed due to the described influence of the negative ions. (auth)

**11874** THEORY OF THE CONTRACTION OF POSITIVE COLUMNS. G. Albrecht, G. Ecker, and K. G. Mueller (Universität, Bonn). Z. Naturforsch., 17a: 854-60(Oct. 1962). (In German)

It is experimentally known that with increasing pressure and current the positive column of the glow discharge constricts. A qualitative discussion of the electron particle balance displays certain requirements for the effective diffusion coefficient $D_{eff}$ and the production coefficient $\alpha'_{eff}$ of the electrons. With increasing distance from the axis either the diffusion coefficient $D_{eff}$ should increase or the production term $\alpha_{eff}$ should decrease down to negative values. The extent to which the various physical processes can meet these requirements is discussed. The constriction caused by the presence of negative ions is evaluated from the transport equations. From the solution of an eigenvalue problem, the radial electron density distribution and the electric field as functions of the current, pressure, and radius are obtained. (auth)

**11875** MICROINSTABILITY OF THE MIRROR TYPE IN INHOMOGENEOUS PLASMAS. D. Pfirsch (Max-Planck-Institut fur Physik und Astrophysik, Munich). Z. Naturforsch., 17a: 861-70(Oct. 1962). (In German)

The canonical momentum in the direction of the electrical current or another ordered motion is a constant of motion in the case of mirror type perturbations of plasma configurations in which the current and the magnetic field are perpendicular to each other and in which all the macroscopic quantities depend only on one coordinate in a rectangular system of coordinates, of which the metrical tensor depends also on that coordinate only. This fact enables one to discuss rather simply the onset of instabilities of that kind of perturbations within the frame of a microscopic collisionless theory. Several examples like plane and cylindrical z and Θ pinches and plane periodic configurations without space charges or without currents are treated in this way. A special result is that at least a very wide class of the nonlinear electrostatic waves, found by Bernstein, Green and Kruskal are unstable. (auth)

**11876** THE PROBE THEORY AT AVERAGE AND LOW PRESSURES. Guenther Schultz (Universität, Saarlandes, Saarbrucken, Ger.). Z. Physik, 170: 196-211(1962). (In German)

At average and low pressures, the charge transport in a space-charge zone, which is formed around a small plane or cylindrical probe in a quasineutral plasma and which shields the field of the probe completely, is not determined through the electrical field strength but essentially through the density gradient of the charge carrier. It was shown that in joining of space-charge and transport equations the diffusion of the oppositely charged particles must be considered, and accordingly in the stationary state no (relative) potential minimum can arise in the space-charge layer. Under these assumptions one obtains both in the plane and the cylindrical case a simple analytical expression for the probe characteristic, which was discussed using the example of a probe measurement in the intermediate gas volume of a methane–hydrogen air flame. (tr-auth)

**11877** THE DETERMINATION OF MATERIALS FUNCTION OF A NITROGEN PLASMA AT ATMOSPHERIC PRESSURE TO 15000°K. G. Schmitz and H. J. Patt (Technische Hochschule, Aachen). Z. Physik, 171: 449-62(1963). (In German)

With the help of the so-called polygonal passage method, from 6 measured temperature distributions and the corresponding values of current, field strength, and radiated output per unit length of a symmetrical cylindrical cascade arc, the electric conductivity, the specific radiation, and the thermal conductivity of a nitrogen plasma were determined at atmospheric pressure as a function of temperature to 15000°K. By reversal of the calculation, limits of error for the calculated functions were obtained. The shape of the curve obtained is discussed, from which an attempt was made to find an analytical representation. A comparison was made of theoretical values and the function determined. In this way qualitative agreements and quantitative variations can be partially explained. (tr-auth)

**11878** MAGNETIC SOUND IN PLASMA WITH THERMAL MOTION. I. THE PROPAGATION ACROSS A CONSTANT MAGNETIC FIELD AND DISSIPATION DUE TO THE SCATTERING. V. P. Demidov, D. A. Frank-Kamenetskii, and V. L. Yakimenko. Zh. Tekhn. Fiz., 32: 1184-9(Oct. 1962). (In Russian)

Gas pressure and collision effects on magnetoacustic wave propagation in fully ionized plasma were analyzed. Dispersion equations were developed on the basis of hydrodynamic approximations and physical kinetics. It was shown that strong absorptive effects produced by collisions at near hybrid frequency exist only in the nonreal case of absolutely cold plasma and are eliminated by the motion of heat. Plasma heating magneto-sonic perspectives using mechanisms unrelated to dissipative collision were also studied. (R.V.J.)

**11879** PROPERTIES OF MAGNETIC AREAS IN SYSTEMS WITH HELICAL MAGNETIC FIELD. V. G. Zykov, B. P. Iljenko, E. M. Latsko, I. A. Stepanenko, A. M. Ternopol, V. T. Tolok, and K. D. Sinelnikov. Zh. Tekhn. Fiz., 32: 1190-6(Oct. 1962). (In Russian)

Properties of magnetic surfaces produced by three sets of helical coils were investigated. Experiments were made in a linear cylinder and in a curvolinear stellarator by observing and measuring transverse cross sections of plasma clusters and rotating electron beams injected along the chamber axes. It was noticed that the dimensions of the separation vary as functions of the confining magnetic field and current in coils. The cross sections of rotating electron beams and plasma clusters correspond to the transverse cross sections of magnetic surfaces. (tr-auth)

**11880** DIFFUSION OF CHARGED PARTICLES IN A DENSE PLASMA IN A MAGNETIC FIELD. A. I. Anisimov, N. I. Vinogradov, V. E. Golant, and B. P. Konstantinov (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Techn. Fiz., 32: 1197-1204(Oct. 1962). (In Russian)

Helium plasma decay at $2 \times 10^{-2}$ to $2 \times 10^{-1}$ mm Hg and electron densities of $3 \times 10^{11}$ to $10^{13}$ was studied. The plasma was probed by 9400 to 36 m Hertz radiowaves. The decay constant was determined by the wave propagation time. Moreover, the radial electron distributions were determined by wave reflection as the magnetic field was increased to 1000 gauss. Charged particle diffusion rate was determined using an expression obtained from electron-ion pair collisions. With magnetic fields above 1000 gauss the decay rate was determined by the volume elimination processes. (tr-auth)

**11881** DIFFUSION OF PLASMA IN A MAGNETIC FIELD. S. G. Alikhanov, A. V. Komin, G. G. Podlesnyi, and G. L. Khorasanov (Inst. of Physics and Tech., Academy of Sciences, Georgian SSR). Zh. Tekhn. Fiz., 32: 1205-11 (Oct. 1962). (In Russian)

Decaying helium plasma produced by high-frequency discharge was investigated. The plasma lifetime was measured as a function of magnetic field intensity to 5000 gauss at neutral gas pressures from $2.5 \times 10^{-2}$ to $2 \times 10^{-1}$ mm Hg. The results are in agreement with pair-interaction diffusion theory. The diffusion coefficient for $H^+$ in the absence of a magnetic field is $D_\alpha = 540$ cm$^2$/sec. (tr-auth)

**11882** ON THE PIPE-PINCH STABILITY. V. V. Vladimirov and P. M. Marchuk (Inst. of Physics, Kiev). Zh. Tekhn. Fiz., 32: 1212-15(Oct. 1962). (In Russian)

Studies were made of cylindrical pinch stability in a Triex system in which a plasma cylinder is distributed between a co-axial internal current carrier (radius C) and a conducting jacket (radius R). The study was carried out on the basis of ideal magnetohydrodynamics equations for incompressible fluid. Dispersion equations were developed for arbitrarily distributed fields with low initial discharge current. Stability criteria were found for various field distributions. (tr-auth)

**11883** DEFINITION OF PLASMA PARAMETERS IN Ne–Hg MIXTURE. K. S. Mustafin and V. I. Protasevich (Tadzhik State Univ., USSR). Zh. Tekhn. Fiz., 32: 1216-22(Oct. 1962). (In Russian)

The temperature and concentration of electrons in a Ne–Hg plasma mixture at neon pressures of 0.5 to 1 mm Hg and mercury pressures of $10^{-3}$ to $10^{-2}$ mm were determined by a probe method. The mean electron energy and drift

rate were calculated by means of electron distribution rate functions, considering elastic and inelastic interactions. (tr-auth)

**11884** ENERGY DISTRIBUTION OF ELECTRONS AND IONS IN A STRONG CURRENT TOROIDAL DISCHARGE. E. A. Lobikov and A. I. Nastyukha. Zh. Tekhn. Fiz., 32: 1223-9(Oct. 1962). (In Russian)

Measurements of electron and ion energy distributions along the axis of a strong toroidal discharge are described. The distribution dependence on discharge parameters was investigated. The asymmetry along the electron and ion flux distributions is related to the presence of an electric field in the discharge. The temperature and drift rate of electrons and ions along the electric field were determined. (tr-auth)

**11885** PENETRATION OF A HIGH-FREQUENCY TRAVELING MAGNETIC FIELD INTO PLASMA. R. A. Demirkhanov, N. I. Leontev, V. V. Logvinov, and Yu. K. Udovichenko (Inst. of Physics and Tech., Academy of Sciences, Georgian SSR). Zh. Tekhn. Fiz., 32: 1248-53(Oct. 1962). (In Russian)

The penetration of high-frequency (900 kc) electromagnetic field into hydrogen plasma at up to 9% ionization was experimentally tested. The frequency of electron–atom–ion interactions was considerably higher than the frequency of electromagnetic waves. The depth of the plasma skin was determined by the same means as for metallic conductors. The conductivity ($\sim 10^{14}$CGSE) calculated for the skin layer was in agreement with data obtained for the electron temperature and particle concentrations. (tr-auth)

**11886** ENERGY LOSSES OF A CHARGED PARTICLE MOVING ABOVE PLASMA IN VACUUM. F. G. Bass, S. I. Khankina, and V. M. Yakovenko (Inst. of Radiophysics and Electronics, Khar'kov). Zh. Tekhn. Fiz., 32: 1254-8(Oct. 1962). (In Russian)

The motion of a charge in a vacuum parallel to the vacuum–electron–ion plasma interface was studied, considering spatial dispersion. Various expressions were derived for energy losses and for deflecting forces affecting it. (tr-auth)

**11887** ON THE STATIONARY STATE OF AN AXIAL SYMMETRICAL SYSTEM OF CHARGED PARTICLES. O. I. Yarkovoi. Zh. Tekhn. Fiz., 32: 1285-90(Nov. 1962). (In Russian)

A self-consistent non-interacting system of axially symmetric charged particles was investigated. The distribution function is assumed to be a function of two known integrals for single particle motion. A nonlinear equation system was obtained for a self-consistent field under the assumption that all particles have identical motion integrals. The feasibility of a normalized solution for the system was analyzed, and a state, limited in all three dimensions, was found for densities in tangible plasma installations. Certain related problems (with a charge compensated by counter-charged particles, etc.) were also solved. (R.V.J.)

**11888** ON THE STABILITY OF STATIONARY LONGITUDINAL OSCILLATIONS OF A PLASMA. V. N. Oraevski and R. S. Sagdeev. Zh. Tekhn. Fiz., 32: 1291-6(Nov. 1962). (In Russian)

A method was developed for investigating stable, nonlinear, nonattenuating, periodic, small-amplitude plasma motions. The method was used for determining the stability of nonlinear longitudinal electron and ion plasma oscillations. The instability resembled quasiparticle decay. The criterion for instability was found, and it was shown that ion oscillations are stable in relation to arbitrary longitudinal oscillation excitation, while electron longitudinal oscillations are unstable in relation to simultaneously excited longitudinal ion and electron oscillations (of a different frequency). An additional instability of longitudinal electron waves was observed in a plasma in a magnetic field. The latter are unstable in relation to the excitation of two transverse electromagnetic waves (with a certain relation between magnetic field and plasma parameters). The increments of certain types of instabilities were evaluated. (R.V.J.)

**11889** ON THE STABILITY OF A WEAKLY IONIZED NONUNIFORMLY HEATED PLASMA IN A HOMOGENEOUS MAGNETIC FIELD. A. V. Timofeev. Zh. Tekhn. Fiz., 32: 1297-1301(Nov. 1962). (In Russian)

Stability of weakly-ionized plasma in a homogeneous external magnetic field without longitudinal current was studied. It is shown that the plasma becomes unstable when the densities of ionized components and electron temperatures vary across the field and when their gradients are parallel. (R.V.J.)

**11890** INVESTIGATION OF A DIFFUSION DECAY OF A PLASMA IN A MAGNETIC FIELD. [PART] III. V. E. Golant and A. P. Zhilinskii (Kalinin Polytechnic Inst., Leningrad). Zh. Tekhn. Fiz., 32: 1313-23(Nov. 1962). (In Russian)

Helium plasma decay in a magnetic field at concentrations affected by nonlinear processes (diffusion induced by electron-ion collisions and recombination) was investigated. It was found that the rate of diffusion induced by electron-ion collisions is in agreement with theory. The influence of metal walls on the rate of plasma decay was determined and the conditions affecting plasma diffusion were found. (tr-auth)

**11891** COEFFICIENTS OF DYNAMICAL FRICTION AND DIFFUSION IN A PLASMA. A. G. Sitenko and Chien Yu Tai (Khar'kov State Univ.). Zh. Tekhn. Fiz., 32: 1324-32(Nov. 1962). (In Russian)

An investigation was made of dynamic friction and diffusion processes in plasma. General formulas expressed by a spectral distribution of longitudinal electric field fluctuations were derived for dynamic friction and diffusion coefficients. Calculations were made of dynamic friction and diffusion coefficients for two-temperature electron-ion plasmas. The time for two-temperature plasma relocations was determined, and the influence of constant external magnetic field was evaluated. (R.V.J.)

**11892** TOPOGRAPHY OF MAGNETIC FIELD, INDUCTION CURRENT, AND HYDROMAGNETIC OSCILLATIONS OF PLASMA IN A PULSED ELECTRODELESS DISCHARGE. M. D. Gabovich and I. M. Mitropan (Inst. of Physics, Kiev). Zh. Tekhn. Fiz., 32: 1371-5(Nov. 1962). (In Russian)

Radial motion of a plasma loop in a pulsed electrodeless discharge was investigated by means of mobile belts and magnetic probes. Data were obtained on time variations in magnetic field topography, including power lines confined in plasma. The effect of a compensating static magnetic field was also studied. (R.V.J.)

**11893** SEPARATE MEASUREMENTS OF RADIATION AND PARTICLE ENERGY LOSSES IN A PLASMA. L. L. Gorelik and V. V. Sinitsin. Zh. Tekhn. Fiz., 32: 1406-8 (Nov. 1962). (In Russian)

A bolometer and gaseous filter were used in separate measurements of plasma radiation and low-energy particle dissipation. A toroidal beta chamber (21.6-cm in diameter, $H_z = 600$ gauss, electric field intensity ~4 v/cm, and hydrogen pressure 3 to $4 \times 10^{-3}$ mm Hg) was used in the experiment. The results are given and discussed. (R.V.J.)

**11894** FIZIKA PLAZMY I PROBLEMY UPRAVLYAEMOGO TERMOYADERNOGO SINTEZA (DOKLADY I KON-

FERENTSII PO FIZIKE PLAZMY I PROBLEME UPRAVLYAEMYKH TERMOYADERNYKH REAKTSII). (Plasma Physics and Problems of Controlled Thermonuclear Fusion. (Reports of the First Conference on Physics of Plasma and Problems of Controlled Thermonuclear Reactions)). Kiev, Publishing House of the Academy of Sciences, 1962. 176p.

Thirty-seven papers are included. The papers deal with high-frequency properties and stability of plasma; magnetohydrodynamics, shock waves and plasma bunches, magnetic traps and gas discharge, applications of low-temperature techniques in investigations of thermonuclear reactions, and plasma diagnostics. (R.V.J.)

## Shielding

**11895** (AE-92) THE BACKSCATTERING OF GAMMA RADIATION FROM PLANE CONCRETE WALLS. M. Leimdoerfer (Aktiebolaget Atomenergi, Stockholm). Dec. 1962. 16p.

Monte Carlo calculations were performed for source energies from 1 to 10 Mev, and normally incident radiation, showing that 90% of the infinite-barrier energy flux albedo is reached with a 10-cm concrete wall. The spectrum of back-scattered energy flux is presented for the above sources and wall thicknesses ranging from 5 to 50 cm. An analytical expression, based on a single-scattering approximation, is shown to produce good fits to the Monte Carlo results. (auth)

**11896** (AE-93) BACKSCATTERING OF GAMMA RADIATION FROM SPHERICAL CONCRETE WALLS. M. Leimdoerfer (Aktiebolaget Atomenergi, Stockholm). Jan. 1963. 11p.

The Monte Carlo technique was applied to investigate the effect of wall curvature on the backscattering properties of concrete. The wall was considered infinitely thick and the source radiation was normally incident. Monte Carlo calculations were only performed at 1 Mev source energy, but an analytical formula was derived to facilitate extrapolations to other energies as well as materials. The results show that for practical purposes the plane wall albedo is a sufficient, and conservative, approximation, 90% of its value being reached at a concrete wall radius of about 100 cm for source energies up to 10 Mev. (auth)

**11897** (AE-94) MULTIPLE REFLECTION OF GAMMA RADIATION IN A SPHERICAL CONCRETE WALL ROOM. Martin Leimdoerfer (Aktiebolaget Atomenergi, Stockholm). Dec. 1962. 17p.

The Monte Carlo method was applied for the calculation of the energy flux of scattered gamma radiation in a spherical room surrounded by an infinitely thick spherical wall and with a point source at the center. Source energies were 1, 2, 4, 6, and 10 Mev. The main investigation was carried out at a room radius of 400 cm but, for the 1 Mev source, the influence of varying the room radius down to 1 cm was analyzed. The results contain energy distributions of the first four successive reflection components at the center of the room and at the wall surface, as well as spatial distributions of the successive energy flux components. The neglect of reflection contributions of order five and higher was estimated to introduce an error of less than 0.2% of the total scattered energy flux. An analytical approximation is shown to produce a useful and easily applicable method of predicting the amount of scattered radiation in a spherical room. (auth)

**11898** (N62-10900(Pt.III)) PRIMARY PROTON PROTECTION. PART III. GEOMETRY, ENERGY, AND MINIMUM WEIGHT. Space Mechanics Memo No. 104. Norris F. Dow (General Electric Co. Missile and Space Vehicle Dept., Philadelphia). Sept. 1961. Contract NASr-34. 25p.

Methods are developed for the evaluation of the efficiency (on a weight basis) of shielding for energetic protons. A loading index is derived against which the weight of passive shielding is measured directly for various shield shapes and materials, and various directionalities and energies of particles. The proper use of the same loading index approach is suggested to lead to a valid evaluation of the weight efficiency of any type of shielding system for any combination of geometries and energies encountered. (auth)

**11899** (N62-10900(Pt.IV)) PRIMARY PROTON PROTECTION. PART IV. ISOTROPIC PARTICLES, AND ELECTROMAGNETIC SHIELDING. Space Mechanics Memo No. 105. Norris F. Dow (General Electric Co. Missile and Space Vehicle Dept., Philadelphia). Dec. 1961. Contract NASr-34. 17p.

An active, superconducting, contained-magnetic-flux, radiation shielding system for isotropic protons is evaluated for a range of volumes to be shielded, and for a series, of discrete particle energies. The system is shown to be of interest for high-energy (greater than approximately 200 Mev) particles, and for large volumes (greater than about 4 $m^3$, or less at higher energies). The containment of the magnetic flux within the coil windings reduces current requirements and hence current-induced stresses and also reduces the problem of possible interactions between the intense magnetic fields and anything therein adjacent to the shield. (auth)

**11900** (NARF-62-16T) ENERGY AND ANGULAR DISTRIBUTION EXPERIMENT. VOLUME I. ANGULAR DISTRIBUTION OF REACTOR RADIATION FROM SLABS AND OF EMERGENT SECONDARY GAMMA RAYS. G. T. Western (General Dynamics/Fort Worth. Div. of General Dynamics Corp., Fort Worth, Tex.). Dec. 31, 1962. Contract AF(657)-7201. 70p. (FZK-9-183-1)

Radiation from the Aerospace Systems Test Reactor positioned within the Outside ASTR Tank was directed, with a narrow-beam slab goemetry, at specimens of 3% borated polyethylene and lead. Measurement data for polyethylene and lead are reported concerning the radiation source term, the flux distribution of thermal and fast neutrons within the test materials, the angular distribution of thermal- and epithermal-neutron flux, fast-neutron dose rate, secondary gamma rays from the test materials, and the reflection of neutrons from borated polyethylene and from steel. (auth)

**11901** (NP-12455) A SEMIEMPIRICAL FORMULA FOR DIFFERENTIAL DOSE ALBEDO FOR GAMMA RAYS ON CONCRETE. A. B. Chilton and C. M. Huddleston (Naval Civil Engineering Lab., Port Hueneme, Calif.). Nov. 16, 1962. 24p. (R-228)

A semiempirical formula was developed which yields values for the differential dose albedo of gamma rays on concrete. Gamma rays of incident energies 0.2, 0.5, 1.0, 2.0, 4,0, 6.0, and 10.0 Mev were considered. Results of the formula were compared with values derived from Monte Carlo calculations for the backscattering of gamma rays from a semi-infinite slab of concrete. Results show that a two-parameter formula gives satisfactory agreement with the Monte Carlo calculations. The principal assumption involved in the theoretical analysis is that the actual reflection process can be approximated by two terms, one involving a single Compton scattering event, and the other involving isotropic scattering. (auth)

**11902** (ORNL-3317) SPACE VEHICLE SHIELDING STUDIES. CALCULATIONS OF THE ATTENUATION OF A MODEL SOLAR FLARE AND MONOENERGETIC PROTON BEAMS BY ALUMINUM SHIELDS. R. G. Alsmiller, Jr. and J. E. Murphy (Oak Ridge National Lab., Tenn.). Jan. 23, 1963. Contract W-7405-eng-26. 117p.

Using the straight-ahead approximation, nucleon-meson cascade calculations have been carried out for a typical proton flare spectrum incident on a shield and for approximately monoenergetic incident proton beams. The shield material considered has approximately the properties of Al. The results from the monoenergetic beams may be used to obtain shielding information for any incident proton spectrum. (auth)

**11903** (UCRL-10475) PORTLAND CEMENT FOR A LOW-BACKGROUND COUNTING FACILITY. Harold A. Wollenberg, Jr. and Alan R. Smith (California. Univ., Berkeley. Lawrence Radiation Lab.). Oct. 1, 1962. Contract W-7405-eng-48. 32p.

A search was conducted for a Portland cement adequately low in radioactivity for use in the construction of a low-background counting enclosure. Raw materials from the operating cement plants in California and finished products from over 80 plants in the United States and Canada were subjected to gamma spectrographic evaluation. The raw-materials study of 138 samples indicated that limestone, the principal cement ingredient, is low in radioactivity compared with sources of alumina and silica. Uranium is the principal contributor of gamma radioactivity in limestone, while thorium is the principal contributor in cement-plant "shale" material. When the K contribution to the total gamma spectrum is normalized to a value of 1, the averaged K : U : Th contribution ratio for limestone is 1.0 : 14.4 : 4.5; for "shale", 1.0 : 1.2 : 2.2; and for cement products, 1.0 : 10.0 : 4.15. (auth)

**11904** LEAD SHIELDINGS FOR RADIOACTIVE SUBSTANCES. Werner Burbach. A E G Mitt., 52: 115-18 (1962). (In German)

The basic law, $I = I_0 e^{\mu \cdot \rho \cdot d}$, for attenuation of emitted radiation where $\rho$ is the density and d is the thickness of the absorber, is illustrated in an example using $Cs^{137}$ ($E_\gamma$ = 0.661 Mev) as the radiation source and Pb ($\rho$ = 11.3 g/cc) as the shielding material. The thickness of the Pb plates surrounding the source was assumed to be 45 cm, and the question arose as to whether this constituted adequate protection. Since the dosage rate, D, at a certain place depends on the dosage constant of the emitter, $A\gamma$, its activity, A, the distance between the radiation source and the place in question, a, as well as on the attentuation factor, S, then $D = AC/a^2S$ is obtained. This calculation can be made easily. Material, which shows the dependence of D on the activity for $Cs^{137}$ and $Co^{60}$, the $\gamma$-emitters most commonly used industrially, is given for making the calculation. (P.C.H.)

## Theoretical Physics

**11905** (JINR-E-1095) REGGE-POLES AND PERTURBATION THEORY. II. B. A. Arbuzov, B. M. Barbashov, A. A. Logunov, Nguyen Van Hieu, A. N. Tavkhelidze, R. N. Faustov, and A. T. Filipov (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics). 1962. 6p.

It is noted that in recent years the problem of how to find the singularities of partial-wave amplitudes in the 1-plane was widely discussed. An analysis of the structure of the perturbation series terms in the presence of branch cuts in the 1-plane is presented by the example of the electron scattering in the Coulomb field. It is shown how the expansions in the charge for the Regge trajectories can be obtained in the case under consideration. (J.R.D.)

**11906** (NP-12434) GROUPS AND THEIR APPLICATIONS TO SPECTROSCOPY. Some Lectures Delivered in the Autumn of 1957 by B. F. Bayman at Universitetets Institut for Teoretisk Fysik and NORDITA Copenhagen. Second Edition. (Nordisk Institut for Teoretisk Atomfysik, Copenhagen). 1960. 225p.

Twenty lectures are presented on the application of group theory to the quantum mechanical time-independent many-body problem. The lectures are based on Wigner's 'Gruppentheorie' and on Racah's contributions. (D.L.C.)

**11907** (TID-15885) RANDOM PATHS ON PLANE NETS WITH INTERNAL TRAPS. G. L. Montet (Argonne National Lab., Ill.). Apr. 1962. Contract [W-31-109-eng-38]. 20p. (UAC-6281)

The problem of a random walk on a plane net containing internal traps in addition to trapping boundaries is discussed. It is shown that solutions to this problem may be formulated in terms of the solutions to the corresponding problem of a random walk on the same net with no internal traps. Illustrations of the solutions for several cases of interest are given. (auth)

**11908** VIRIAL THEOREM AND ITS GENERALIZATIONS IN SCATTERING THEORY. Peter D. Robinson and Joseph O. Hirschfelder (Univ. of Wisconsin, Madison). Phys. Rev., 129: 1391-6(Feb. 1, 1963).

Heretofore, the hypervirial theorems recently introduced by Hirschfelder have only been applied to bound-state systems. In this paper it is shown that, with certain modifications, these theorems can also be applied to free systems, and, in particular, to scattering problems. The new form of the general hypervirial theorem is derived, and the theory is illustrated with the problem of a particle scattered by a central field. The ordinary virial theorem is deduced, together with other results of physical interest. Both classical and quantum-mechanical formalisms are considered, and in some cases the semiclassical approximation links corresponding results. (auth)

**11909** HYPERVIRIAL THEOREMS FOR VARIATIONAL WAVE FUNCTIONS IN SCATTERING THEORY. Saul T. Epstein (Univ. of Nebraska, Lincoln) and Peter D. Robinson. Phys. Rev., 129: 1396-8(Feb. 1, 1963).

The form of hypervirial theorem which is appropriate in scattering theory is discussed in general terms. It is shown that variational wave functions which are optimized in accordance with Kohn's variational principle do satisfy hypervirial theorems. Thus such theorems may be useful in selecting approximate wave functions to give accurate phase shifts or scattering amplitudes. The situation is analogous to that of energy-optimized wave functions for bound-state systems. (auth)

**11910** DELTA-FUNCTION POTENTIAL IN A BOX. Bruce L. Scott (Univ. of Southern California, Los Angeles). Phys. Rev., 129: 1411-14(Feb. 1, 1963).

The problem of a particle interacting with a potential of delta-function shape and having a tensor component is considered for box boundary conditions. The limits of small potential and large box dimensions are considered, especially in their effect on the mixing parameter. (auth)

**11911** QUANTIZATION OF THE ELECTROMAGNETIC FIELD. Tai Tsun Wu (Brookhaven National Lab., Upton, N. Y.). Phys. Rev., 129: 1420-3(Feb. 1, 1963).

A method of quantizing the electromagnetic field is proposed, where the underlying Hilbert space has a definite

metric and the verifications of Lorentz covariance can be easily carried out with the help of Ward's identify. The usual Feynman-Dyson rules are obtained for the electron-photon system, and the longitudinal and scalar photons are found to have separately no interaction with the electron field. (auth)

**11912** UNITARITY AND HIGH-ENERGY BEHAVIOR OF SCATTERING AMPLITUDES. A. Martin (Univ. of Washington, Seattle and CERN, Geneva). Phys. Rev., 129: 1432-6(Feb. 1, 1963).

Upper and lower bounds of the imaginary part of a scattering amplitude are obtained for physical and unphysical values of the scattering angle, respectively, from unitarity alone. This imposes rather stringent conditions on the high-energy behavior of the scattering amplitude. In particular unitarity alone rules out Regge poles with value larger than unity for zero momentum transfer. On the other hand, it is shown that the total cross section cannot increase faster than the logarithm squared of the energy under assumptions appreciably more general than Mandelstam representation. Finally, in the light of the preceding results, a few comments are given on the problem of the shrinking of the diffraction peak and its connection with the decrease of the elastic cross section. (auth)

**11913** ANGULAR MOMENTUM POLES OF THE NON-RELATIVISTIC S MATRIX FOR SPIN ½ PARTICLES. Bipin R. Desai and Roger G. Newton (Indiana Univ., Bloomington). Phys. Rev., 129: 1437-44(Feb. 1, 1963).

The study of the structure of the two-particle S matrix as a function of the angular momentum in potential theory is extended to spin-dependent interactions between two spin ½ particles, including the tensor force. The results reveal considerable similarity with the spin zero case, including the symmetry properties. The main differences are two branch points at $j = 0$ and $j = -1$ and a pole at $j = -\frac{1}{2}$. It is shown that judicious combinations of S-matrix elements contain none of these singularities, and, as a result, neither do the scattering amplitudes. Certain modifications of the canonical situation are found in the presence of spin-orbit forces or other orbital angular momentum-dependent potentials. The factorization of the residue of the S matrix is also discussed. (auth)

**11914** REPRESENTATIONS FOR THE S MATRIX IN TERMS OF ITS ANGULAR MOMENTUM POLES. Bipin R. Desai and Roger G. Newton (Indiana Univ., Bloomington). Phys. Rev., 129: 1445-52(Feb. 1, 1963).

The asymptotic distribution of poles of the nonrelativistic S matrix for potential scattering in the complex angular momentum plane is investigated, and so is the nature of the pole trajectories near $E = 0$. As a consequence of the behavior of the distant poles and of their residues the S matrix is shown to be representable in the form of an infinite (Weierstrass-Hadamard) product as well as in the form of a (Mittag-Leffler) series of partial fractions. (auth)

**11915** TWO POMERANCHUK-REGGE TRAJECTORIES. Graham Frye (Univ. of Washington, Seattle). Phys. Rev., 129: 1453-8(Feb. 1, 1963).

The existence of two Pomeranchuk-Regge trajectories is conjectured. It then follows, with a single numerical coincidence, that at high energies the scattering in each angular momentum state is dominated by inelastic processes. This reinstitutes the physical plausible semiclassical explanation of the origin of diffraction scattering. The width of the diffraction peak still shrinks with energy. It also follows that both total and elastic cross sections increase logarithmically, with a limiting ratio of approximately four. The real part of each phase shift approaches an integral multiple of $\pi$, providing a basis for a general Levinson's theorem; the approach is from above as $(\ln E)^{-1}$ for increasing energy E. The inelastic scattering in each partial wave approaches its maximum value only as $(\ln E)^{-2}$. Rough quantitative estimates indicate that the typical contribution of two Pomeranchuk trajectories to a total cross section might be quite large (of the order of 66 mb) at 20 Bev. (auth)

**11916** THE CLASSICAL LIMIT OF THE QUANTUM THEORY OF RADIATION DAMPING. Jack E. Chatelain and Peter Havas (Lehigh Univ., Bethlehem, Penna.). Phys. Rev., 129: 1459-63(Feb. 1, 1963).

The classical limit of the quantum theory of damping (without radiative corrections) has been studied for scattering procedures involving photons and neutral or charge-symmetric mesons [with S(S), PS(PV), V(V), and V(T) coupling] interacting with nucleons. In the case of dipole coupling the nuclear spin $\frac{1}{2}\hbar$ must be replaced by a classical intrinsic angular momentum, and classical rather than quantum mechanical averages over spin variables must be taken. The cross sections are then calculated taking classical limits at all stages rather than just in the summation over the final stages. Comparison is made with the corresponding results in the classical field and action-at-a-distance theories; the cross sections agree with those of the theory of action at a distance in all cases for which these results are available. (auth)

**11917** ANGULAR MOMENTUM TRANSPORT IN QUANTUM STATISTICAL MECHANICS. John S. Dahler (Univ. of Minnesota, Minneapolis). Phys. Rev., 129: 1464-8(Feb. 1, 1963).

Equations of motion are derived for the many-body operators associated with local densities of linear and angular momentum. It is illustrated that the transfer equations for orbital and spin angular momentum are formally identical. Finally, an approximate theory is developed for the elastic tensor of diatomic media or media composed of atoms with intrinsic spin. (auth)

**11918** POSITIVE-DEFINITE ENERGY DENSITY AND GLOBAL CONSEQUENCES FOR GENERAL RELATIVITY. Arthur Komar (Syracuse Univ., N. Y.). Phys. Rev., 129: 1873-6(Feb. 15, 1963).

An expression for energy density in general relativity is constructed starting from the viewpoint that such an expression should be represented by the generator of translations of a preferred set of spacelike coordinate surfaces. The resulting expression is shown to yield a positive-definite value for the energy. It is further shown that, in conformity with one version of Mach's principle, if the total energy vanishes, the space is locally flat. (auth)

**11919** REGGE TRAJECTORY IN FIELD THEORY. Lu Sun Liu and K. Tanaka (Argonne National Lab., Ill.). Phys. Rev., 129: 1876-9(Feb. 15, 1963). (TID-17453; UAC-6917)

The form of the Regge trajectory, the graph of the complex angular momentum $\alpha(t)$ as a function of the square of the momentum transfer t, is studied in field theory within the framework of the ladder approximation in the crossed channel. To order $g^2$, the trajectory is unbounded in the region $t \approx 4m^2$, but inclusion of the higher-order terms in $g^2$ removes the divergence and leads to a smooth trajectory that resembles that expected from potential scattering. The various relations between $g^2$, $\alpha(t)$, and the exchanged mass are discussed. (auth)

**11920** RELAXATION PHENOMENA IN SPIN AND HARMONIC OSCILLATOR SYSTEMS. Jayaseetha Rau (Brandeis Univ., Waltham, Mass.). Phys. Rev., 129: 1880-8(Feb. 15, 1963).

A method is developed for generating relaxation by introducing a fundamental interval $\tau$ and a stirring hypothesis. The application to spin and harmonic oscillator systems is discussed in some detail. All the results are obtained by exact calculations without applying perturbation theory as the systems considered are simple and completely soluble. Equations similar to phenomenological Bloch equations are derived in the case of spin systems. The relaxation times obtained by the application of the theory are not only proportional to the strength of interaction, but also to the fundamental interval $\tau$ which plays an important role in the theory. It is shown that in the case of a harmonic oscillator system, an initial Boltzmann distribution relaxes to a final equilibrium Boltzmann distribution through a sequence of transient Boltzmann distributions. (auth)

**11921** SIMULATION OF THE HARD CORE BY A VELOCITY DEPENDENCE. Steven A. Moszkowski (Univ. of California, Los Angeles). Phys. Rev., 129: 1901-4 (Feb. 15, 1963).

Recently, Green has shown explicitly that different potentials which fit the same S-wave phase shifts from 0 to 250 Mev (lab system) can give quite different binding energies of nuclear matter. In this paper it is shown for two particular potentials, a velocity-dependent one vs one with a hard core, how this different behavior is related to the form of the two-particle wave function at small interparticle distances. The equality of the phase shift vs energy for two potentials requires that the two-particle wave function must have not only the same asymptotic form but also the same value of an effective-range integral, which places some constraint on the form of the interior wave function as well. It is shown that the potentials give also nearly the same results to first order in the "separation method," an approximation to the treatment of nuclear matter in which the wave function is assumed to equal the interior wave function at short distances joining on smoothly with the unperturbed wave function at a distance of about 1 F. However, the change in the particle propagator due to the velocity dependence of the nucleon-nucleus potential gives a positive contribution to the energy, which depends on the wave function at short distances. This contribution is much bigger for the hard-core potential than for the velocity-dependent one, since there is more of a short-range correlation effect in the former case. (auth)

**11922** BOUNDS ON MOMENTUM DEPENDENCE OF PHASE SHIFTS AND MAGNITUDE OF COUPLING CONSTANTS. Adam M. Bincer and Bunji Sakita (Univ. of Wisconsin, Madison). Phys. Rev., 129: 1905-10(Feb. 15, 1963). (TID-16787)

The analytic structure of partial-wave amplitudes is used to derive a dispersion relation for the scattering phase shift. This dispersion relation is used to obtain a lower bound on the momentum derivative of the phase shift. The bound depends on an integral over the unphysical (left-hand) cut in the momentum squared plane and can be expressed in terms of the number of zeros of the real part of the S matrix along the unphysical cut. Stronger bounds are also presented involving the position of these zeros and the locations and widths of resonances and virtual states. The same approach is used to obtain limits on the magnitude of coupling constants. (auth)

**11923** MATHEMATICAL FOUNDATION OF THE QUANTUM THEORY OF INTERACTING FIELDS. Hitoshi Wakita (Hiroshima Univ.). Progr. Theoret. Phys. (Kyoto), 28: 80-6(July 1962). (In English)

Assuming that the interaction between two fields takes place in the primary system, the interaction Hamiltonian density with primary operators is written. Then this density becomes a well-defined operator in the primary system, and the Schrödinger equation becomes mathematically meaningful. Since the proper system, that is, the physical system in the usual sense, is contained in the extension of the primary system, this Schrödinger equation also has a precise mathematical meaning in the proper system. It is proved that the derived interaction Hamiltonian is equivalent to the renormalized conventional interaction Hamiltonian. (auth)

**11924** ON THE STRENGTH OF THE COUPLING CONSTANT AND THE STABILITY OF THE VACUUM. Kazumi Maki (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 28: 942-3(Nov. 1962). (In English)

Recently in connection with the S matrix theory of strong interactions, Chew and Frautschi conjectured that the strength of the coupling constant may be determined from the unitarity condition and the postulate of the maximal analyticity of the scattering amplitude. Here it is shown, by use of the Bethe-Salpeter equation, that the upper bound of the strength of the coupling is to be determined for some simple models within the framework of quantum field theory on the postulate that the vacuum should be stable. (W.D.M.)

**11925** A SEMI-CLASSICAL PICTURE FOR THE HIGH-ENERGY SCATTERING. Masakuni Ida (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 28: 943-4(Nov. 1962). (In English)

Some results on high-energy scattering are reported which were obtained by using a semi-classical picture without any specific approximation. Spins and isotopic spins were neglected for simplicity and because they are of minor importance at very high energies. (W.D.M.)

**11926** THE CONDITIONS FOR A QUANTUM FIELD THEORY TO BE RELATIVISTIC. P. A. M. Dirac (St. John's Coll., Cambridge, Eng.). Rev. Mod. Phys., 34: 592-6(Oct. 1962).

A quantum field theory in agreement with special relativity can be built up from the infinitesimal operators of translation and rotation. These operators are expressible in terms of a momentum density and an energy density. The momentum density is determined by the geometrical properties of the fields concerned. The energy density has to satisfy commutation relations for which certain conditions hold. (auth)

**11927** THE WIGNER DISTRIBUTION FUNCTION AND SECOND QUANTIZATION IN PHASE SPACE. Wesley E. Brittin and Willard R. Chappell (Univ. of Colorado, Boulder). Rev. Mod. Phys., 34: 620-7(Oct. 1962).

The purpose of this review is to introduce the phase space operators for a system of particles in a natural way, to show various relationships satisfied by them, to show their relation to the Wigner distribution function, and finally to consider distribution functions for a system of charged particles including the quantized electromagnetic field. (W.D.M.)

**11928** WIGNER COEFFICIENTS FOR THE $SU_3$ GROUP AND SOME APPLICATIONS. Marcos Moshinsky (Universidad de México, México City). Rev. Mod. Phys., 34: 813-28(Oct. 1962).

A class of Wigner coefficients for the three-dimensional unitary unimodular group ($SU_3$) is determined. The representations of the unitary group in three dimensions $U_3$ are characterized by a partition $[h_1h_2h_3]$. The representations of the $SU_3$ group are characterized by the differences $[h_1-h_3, h_2-h_3]$ of these numbers. The Wigner coefficients are those associated with the Clebsch-Gordan develop-

ment of the Kronecker product of two irreducible representations. (W.D.M.)

**11929** ON THE LOCALIZABILITY OF QUANTUM MECHANICAL SYSTEMS. A. S. Wightman (Princeton Univ., N. J.). Rev. Mod. Phys., 34: 845-72(Oct. 1962).

In Newton and Wigner's formulation, the set $S_a$ of states localized at a point of the three-dimensional space at a given time, must satisfy the following axioms: (a) $S_a$ is a linear manifold; (b) $S_a$ is invariant under rotations about a, reflections in a, and time inversion; (c) $S_a$ is orthogonal to all its space translates; and (d) certain regularity conditions. A proposal is made to reformulate the physical ideas of (a) – (d) in terms of a notion of localizability in a region. (W.D.M.)

**11930** PROBLEMS ON THE FRONTIERS BETWEEN GENERAL RELATIVITY AND DIFFERENTIAL GEOMETRY. John Archibald Wheeler (Kyoto Univ. and Princeton Univ., N. J.). Rev. Mod. Phys., 34: 873-92(Oct. 1962).

The basic principles of general relativity are reviewed in brief outline. Some of the exact solutions of Einstein's equations are reviewed and new insights won from these solutions and new issues that have come to light in this way are cited. These issues are recapitulated in the context of differential geometry. (W.D.M.)

**11931** THE RELATIONSHIP OF THE BISPINOR THEORY TO THE SPINOR THEORY IN RIEMANN SPACE. Ernst Schmutzer (Universität Jena, Ger.). Z. Naturforsch., 17a: 707-11(Sept. 1962). (In German)

In this continuation of three earlier works on the theory of spinors and bispinors in Riemannean space, a general covariant bispinor geometry is developed without using special coordinates or the tedious orthogonal Vierbein-formalism. Departing from the conventional definition of the adjoint bispinor, which was the base of Schrödinger's generalization for the Riemannean space, a new definition of this fundamental notion is given avoiding many difficulties of Schrödinger's theory. The whole theory is coincided with the theory of spinor geometry. So it is possible to find an explicit expression for the bispinor affinities. By this work a formal conclusion of the general covariant analytical apparatus of spinor and bispinor theory and of the mutual relations is obtained. (auth)

**11932** THE SEMICLASSICAL TREATMENT OF SOME QUANTUM PROBLEMS. G. Breit (Yale Univ., New Haven, Conn.). Z. Physik, 171: 149-70(1963). (TID-16416) (In English)

The semiclassical treatment of quantum-mechanical problems is discussed, making use of a generalization of the Hamilton-Jacobi partial differential equation to cases in which only some of the variables of the problem are treated classically. The quantum equations are put into a form in which the effects not covered by the semiclassical approximation are concentrated into one set of terms. This enables corrections to the semiclassical theory to be calculated. It is demonstrated that compensation of the decrease of scattering in the coherent ("elastic") channel by the increase caused by the presence of incoherent ("inelastic") channels which is exact in the semiclassical approximation holds in a certain approximation quantum-mechanically. By means of these relationships it is shown that some and presumably the main contributions to the dynamical effects of molecular electrons interacting with protons in experiments on proton-proton and proton-neutron scattering are negligibly small. (auth)

# REACTOR TECHNOLOGY

## General and Miscellaneous

*Refer also to abstracts 10516, 11109, 11095, 11096, and 12042.*

**11933** (AAEC/E-101) A TWO-GROUP, THREE-REGION, FULLY REFLECTED CYLINDRICAL REACTOR PROGRAM FOR THE IBM 1620. J. J. Thompson and M. Godfrey (Australia. Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). Dec. 1962. 12p.

This program was prepared as a pilot program for a larger computer and handles symmetrical reactors with core, side reflector, and end reflectors, using 10 radial and 10 axial mesh regions. The output consists of the effective multiplication constant, the two flux distributions, and the fission source distribution. The extrapolated Liebmann process is used for the inner iterations. (auth)

**11934** (AERE-R-3453) A SIMPLE APPARATUS FOR SAMPLING CYLINDRICAL GRAPHITE SPECIMENS. G. J. Hunter and M. Perkins (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). Nov. 1962. 16p.

Detailed examination was required of the radial distribution of fission products in cylindrical specimens of graphite cut from irradiated fuel cans. A sampling apparatus constructed to remove very thin layers of graphite from the inner and outer surfaces of such graphite specimens is described. (auth)

**11935** (ANL-6658) REACTOR DEVELOPMENT PROGRAM PROGRESS REPORT, NOVEMBER 1962. (Argonne National Lab., Ill.). Dec. 15, 1962. Contract W-31-109-eng-38.

Developmental activities are reported on the EBWR, Borax-V, ZPR-III, AFSR, EBR-I, EBR-II, and FARET. Progress is also reported in the area of general reactor technology in applied reactor physics, reactor fuel development, reactor materials development, heat engineering, and chemical separations. Information on advanced research and development is included concerning the AARR, undersea applications of nuclear power, conduction-cooled reactor heat sources, and direct conversion. Nuclear safety work is reported on TREAT, thermal reactor safety, and fast reactor safety. (J.R.D.)

**11936** (ANL-6672) REACTOR DEVELOPMENT PROGRAM PROGRESS REPORT, DECEMBER 1962. (Argonne National Lab., Ill.). Jan. 15, 1963. Contract W-31-109-eng-38. 51p.

Research and development progress is reported on water-cooled reactors, liquid-metal-cooled reactors, general reactor technology, plutonium-recycle reactor program, advanced systems research and development, and nuclear safety. (M.C.G.)

**11937** (ARF-4132-16) STUDIES OF REACTOR CONTAINMENT. Summary Report No. 4, August 1, 1960 to January 31, 1961. T. A. Zaker, ed. (Illinois Inst. of Tech., Chicago. Armour Research Foundation). Feb. 1961. Contract AT(11-1)-528. 75p.

A summary of activities for determining the properties and effectiveness of containment structures when subjected to shock or other loads of a transient nature is presented. An examination of the containment problem from the generation of transient loads at the source to the ultimate effects upon the containment is discussed. Experimental investigations of the loads to which external containment structures for nuclear reactors are subjected in the event of a violent incident at the reactor core were conducted. (H.G.G.)

**11938** (BAW-1257) ANALYSIS OF WATER MODERATED $UO_2$ AND $ThO_2$ LATTICES. David B. Wehmeyer (Babcock and Wilcox Co., Lynchburg, Va.). May 1962. Contract AT(30-1)-2602. 49p.

A series of critical and exponential experiments was performed with lattices of fuel rods composed of low-enriched $UO_2$ and fully enriched $UO_2$ in $ThO_2$. These lattices were moderated by $H_2O$ and by mixtures of $D_2O$ and $H_2O$. Measurements made included buckling, ratio of epithermal to thermal capture in $U^{238}$ and $Th^{232}$, ratio of epithermal to thermal fissions in $U^{235}$, ratio of thermal flux in the moderator to that in the fuel, and water height reactivity worth. (J.R.D.)

**11939** (CRL-75) EXPERIMENTAL PARAMETERS FOR NPD AND CANDU TYPE FUEL ELEMENTS IN $D_2O$. R. E. Green, G. A. Beer, B. G. Chidley, C. H. Millar, and P. R. Tunnicliffe (Atomic Energy of Canada Ltd. Chalk River Project, Chalk River, Ont.). Nov. 1962. 27p. (AECL-1640)

Experiments carried out in the ZED-2 reactor to determine lattice parameters for fuel assemblies which are similar to the fuel channels of the NPD and CANDU power reactors are described. Bucklings were determined from macroscopic neutron flux distribution and reactivity measurements. Microscopic neutron flux distribution measurements were made in central lattice cells and the results combined with measurements of the Westcott epithermal neutron spectrum parameter (r) and effective neutron temperatures to determine the thermal utilization (f), and the thermal diffusion area ($L^2$). Fast fission ratios and initial conversion ratios were also measured from which values of the fast fission factor ($\epsilon$) and the resonance escape probability (p), respectively, were deduced. Measurements were made at various fuel assembly spacings in the range 18 to 36 cm in hexagonal lattices. The experimental results were compared with calculated parameters obtained from the latest version of the Chalk River lattice calculation program. (auth)

**11940** (CRRP-895) SOME CLOSE PACKED LATTICES IN LIGHT AND HEAVY WATER—SPECTRUM AND FINE STRUCTURE MEASUREMENTS. W. H. Walker and R. G. Jarvis (Atomic Energy of Canada Ltd., Chalk River, Ont.). Sept. 1962. 102p. (AECL-1625)

Experiments in twelve exponential assemblies of close-packed lattices of natural and depleted U rods in light water and in heavy water are described. In certain of the lattices measurements were made on the spectrum and the spatial variation of the neutron flux at thermal and epithermal energies. The spectra were investigated by irradiating thin and thick foils and wires, bare and under Cd, and the spatial distributions were investigated with wires which were irradiated bare and under Cd. The results of these measurements were compared with the predictions of two theories, the first theory using a conventional spectrum model which has a thermal Maxwellian component fed by a 1/E slowing down component, and the second theory using a heavy gas scattering model to describe the slowing down.

The predictions of the heavy gas model are appreciably more accurate. (auth)

**11941** (EURAEC-475) AN ADVANCED RESEARCH PROGRAM ON THE APPLICATION OF STEAM–WATER SPRAY TO THE COOLING OF LIGHT WATER REACTORS. CAN-2 Quarterly Progress Report No. 5, July 1–September 30, 1962. (Centro Informazioni Studi Esperienze, Milan). Oct. 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 060-61-7-RDI. 14p. (CISE-R-64)

Heat transfer experiments were performed in order to measure critical heat flux in rather long (maximum heated length 150 cm; 0.5 cm ID) and very short (minimum heated length 2 cm; 0.5 cm ID) tubes uniformly heated. Heat transfer coefficients below and above critical heat flux were measured systematically with a good accuracy for an element 80 cm long (0.5 cm ID). A hysteresis effect in heat transfer coefficient below the critical heat flux was also investigated. Critical phenomena in transient heat flux conditions were also studied, varying the power rise to the critical value in times ranging from 0.5–2 seconds up to about 10 seconds. No appreciable effect was found for mass velocities higher than 250 g/cm$^2$ sec. The hydrodynamic loop was operated for investigating the variation of liquid film thickness and pressure gradient with the aperture size of the mixer slot and with various distances from the mixer. It was found that, with a given aperture, both pressure gradient and liquid film thickness decrease with increasing distance from the mixer. Work on the device for measuring the shear stress on the duct wall was pursued and a method was devised for the measurement of the liquid film flow rate. Corrosion experiments are being performed following the established program. Loop no. 1 is being operated for long exposure tests on Zircaloy-2 and stainless steel (5,000 hours to date) as well as for a new series of experiments at higher temperatures, up to 295°C. Some specimens, corroded both in static and dynamic conditions, are being analyzed to determine the absorbed hydrogen content. Corrosion tests with controlled oxygen content in the steam-water mixture are in progress in the loop no. 2. (auth)

**11942** (EURAEC-476) DEVELOPMENT PROGRAM ON THE APPLICATION OF STEAM–WATER SPRAY TO REACTOR COOLING. CAN-3 Quarterly Progress Report No. 3, July 1–September 30, 1962. (Centro Informazioni Studi Esperienze, Milan). Oct. 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 056-62.1-RDI. 12p. (CISE-R-65)

The loop for large scale experiments of heat transfer and hydrodynamics in Genoa is still in the assembling stage. The equipment for the electrical heating of the test element was assembled. The revision of the boiler required more work than foreseen: in particular the economizer was completely rebuilt and a number of substantial changes were carried out in the superheater. The construction of the in-pile loop to be placed in the SORIN reactor is nearly completed. The only component which is still under construction is the test section. Sections of the loop have undergone, separately, preliminary testing. Reliability tests were successfully performed with a mock-up of the container (made of aluminum alloy) of the test section, to be immersed in the reactor pool. (auth)

**11943** (EURAEC-500) STATISTICAL METHODS FOR HOT CHANNEL AND HOT SPOT CALCULATION. Quarterly Progress Report No. 7, July 31, 1962–September 30, 1962. (FIAT. Sezione Energia Nucleare, Turin). Oct. 30, 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 035-60-11RDI. 17p. (FN-E-29)

The spot model approach to the general hot spot problem is reviewed. Distinction was made between the conventional approach, the conventional statistical approach, and the spot model statistical approach. Work was continued on a Monte Carlo code, HYTHEST, to apply the spot model to a boiling-water reactor core. A table was prepared to facilitate numerical comparison of correction factors for the spot model method. (M.C.G.)

**11944** (GAMD-3378) HTGR IN-PILE LOOP EXPERIMENT ACTIVITY ANALYSIS GAIL III-A FUEL ELEMENT. D. R. Lofing and L. R. Zumwalt (General Atomic Div. General Dynamics Corp., San Diego, Calif.). Sept. 28, 1962. Contract AT(04-3)-314. 29p.

The first GAIL fuel element (GAIL-III-A) was installed in a General Electric Test Reactor loop in Sept. 1961 and remained in the loop until Feb. 1962 accumulating an exposure of 133 Mwh of operation. The experiment was taken through a programmed power escalation to around 70 kev. During the course of the experiment, gas samples were taken from the main loop gas stream and from the purge gas stream. Results from fission product counting are given. (W.D.M.)

**11945** (GEAP-4096) HIGH POWER DENSITY DEVELOPMENT PROJECT TENTH QUARTERLY PROGRESS REPORT, JULY–SEPTEMBER 1962. R. L. Holladay (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). Oct. 1, 1962. Contract AT(04-3)-361. 71p.

The high-power-density fuel assemblies continued to accumulate exposure during the reporting period. Average assembly burnup for the entire group is 5,160 Mwd/t. Six assemblies have burnups over 6,000 Mwd/t. Three assemblies, 1E, 1G, and 1D were suspected as a result of sipping techniques to contain fuel rod failures. Examination of these assemblies revealed single fuel rod failures in each. Fuel Fabrication Development. Fabrication of the first Consumers Big Rock fuel assembly was completed. The assembly contains 121 swaged pellet fuel rods clad in 0.010-in.-thick 304 stainless steel. Fabrication is in progress on three additional swaged pellet fuel assemblies. Assembly 3S was found to contain a cracked corner rod similar to those occurring in Task 1A fuel. The corner rods on assembly 3S are 12-mil thick cold worked stainless clad, swaged pellet fuel rods. The remainder of the rods are tandem rolled rods. Assembly of the modified fuel bundles and shipment of the control cubicles and various small parts for the Fuel Instrumentation System was completed. Stability, Heat Transfer, and Fluid Flow. A re-evaluation of stability and transient response analyses was completed. All final core and plant design features were incorporated, as well as some improvements over previously used analyses. Physics Development. The study of axially distributed poison as a method of reducing the axial power peaking factor has continued by consideration of a combination of burnable and permanent poison, and of operational procedures which will give the minimum power peaking factor over the life of the core. Progress with regard to the scheduling computer centered around the calculational portion of the computer sequence. This involves both the physics functions and the thermal-hydraulic functions performed by the computer for the periodic and on-demand logs. (auth)

**11946** (HW-SA-2549) THE DEVELOPMENT OF REACTOR DATA LOGGING SYSTEMS AT HANFORD. R. Sherrard (General Electric Co. Hanford Atomic

Products Operation, Richland, Wash.). [Apr. 23, 1962]. Contract [AT(45-1)-1350]. 27p.

Descriptions concerning the use, previous history, evaluation of philosophy of systems, and details of thermocouple data logging system components are presented. (auth)

**11947** (HW-SA-2558) MEASUREMENT OF SYSTEM TRANSFER FUNCTIONS BY STATISTICAL METHODS—APPLICATION TO HANFORD REACTORS. C. D. Swanson (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Apr. 30, 1962. Contract AT(45-1)-1350. 27p.

The term transfer function is defined. The more common methods of transfer function measurement are reviewed. An application of a statistical method of measurement used to obtain dynamic data on some of the Hanford reactors is described. (M.C.G.)

**11948** (HW-SA-2584) CONSERVATION OF HELIUM BY MEANS OF RADIOACTIVE ARGON MEASUREMENTS. Sterling L. Nelson (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). [May 11, 1962]. Contract [AT(45-1)-1350]. 8p.

Radioactivity measurements of argon in the gas atmosphere circulating through the channels and interstices within a Hanford reactor were investigated as a means of indicating the presence of small quantities of air in the gas. These measurements were found to be valuable in controlling leakage of air into the reactor. They provide a means for controlling internal pressures at very low values without undue risk of air leaking into the reactor. This permits a reduction in helium usage (loss by leakage) through reduction of pressure differentials to minimize leakage without air intake. (auth)

**11949** (IKF-2) EINFLUSS DER VERZÖGERTEN NEUTRONEN AUF DIE FORM DER REAKTOR-ORTSKURVEN. (Effects of Delayed Neutrons on the Shape of the Distribution Curve of the Reactor). U. Kaczmarek (Johann-Wolfgang-Goethe-Universität, Frankfurt am Main. Institut für Kernphysik). June 1962. 25p.

If the distribution curves of water-boiler reactors are calculated using differential equations, they describe its kinetic behavior so that the frequency $\omega \approx 5$ at a characteristic point can be found. It illustrates the supposition that the coordinates of this "singular point" depend somewhat on reactor size. If the dependence of the coordinates on the size were ascertainable as a parameter in a simple way, this characteristic point could be used for control determination for this reactor size. A study was made, for the simple case of a bare reactor, of the influence of 1, 2, and 6 groups of delayed neutrons on the form of the distribution curve. (tr-auth)

**11950** (KAPL-M-EC-28) KWIP—KINETICS WITH PLOTTER. Gerhard O. Mueller (Knolls Atomic Power Lab., Schenectady, N. Y.). Dec. 3, 1962. Contract W-31-109-eng-38. 26p.

KWIP is a digital computer program which calculates the excess reactivity, $\Delta k$, as a function of time using time-dependent reactor flux data as input. Six delay group parameters are built into the program although an input option allows the user to provide his own delay group data if so desired. The excess reactivity is obtained through the solution of the time-dependent reactor kinetics equations. The KAPL Printer Plotter routine is included as an output option for plotting the results. The average running time is one-half second per data point. (auth)

**11951** (KAPL-M-RPC-5) HOTSTICK, KARE AXIAL POWER DISTRIBUTION PROGRAM FOR THE PHILCO 2000. Donald E. Goodman (Knolls Atomic Power Lab., Schenectady, N. Y.). Dec. 1962. Contract W-31-109-eng-52. 13p.

The determination of axial power distributions in suspected "hot channels" is of major interest in nuclear reactor design. HOTSTICK is a Philco 2000 computer program which operates as part of the KARE system to obtain these distributions as a useful adjunct to normal KARE calculations. (auth)

**11952** (NAA-SR-7086) PRODUCTION OF VOID AND PRESSURE BY FISSION TRACK NUCLEATION OF RADIOLYTIC GAS BUBBLES DURING POWER BURSTS IN A SOLUTION REACTOR. P. Spiegler, C. F. Bumpus, Jr., and A. Norman (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Dec. 30, 1962. Contract AT(11-1)-Gen-8. 39p.

The Kinetic Experiment on Water Boiler (KEWB) reactor is a 50-kw aqueous homogeneous research reactor which was designed to study the safety characteristics and dynamic behavior of this class of reactors. When the reactor is placed on a short-period power transient, its aqueous uranyl sulfate fuel solution becomes rapidly supersaturated with $H_2$ gas produced by the radiolysis of water. At a critical gas concentration, fission track nucleation of $H_2$ bubbles occurs. The rapid formation and growth of these bubbles creates a pressure field, the so-called inertial pressure, which causes an increase in solution volume. This increase in solution volume, referred to as void, causes a loss of reactivity and constitutes an important shutdown mechanism. The conditions under which fission track nucleation of gas bubbles occurs are described. It is shown that the void volume and void compensated reactivity can be calculated from a knowledge of the pressure field. Simple models for the pressure field are presented which satisfactorily describe the observed pressures. The inpile capsule and KEWB experiments which confirm the validity of the mechanisms for these processes are described. The equations and data presented make it possible to predict with accuracy the onset and magnitude of the inertial pressure and the dynamic reactivity for a large class of aqueous homogeneous reactors. (auth)

**11953** (NARF-61-45R) TORY-IIA EFFLUENT SAMPLING PROGRAM. Final Report. (General Dynamics/Fort Worth. Div. of General Dynamics Corp., Fort Worth, Tex.). June 22, 1962. Contract AF33(600)-38946. 207p. (AD-277461; FZK-9-177)

A release of trace quantities of fission products was previously postulated as a consequence of the operation of the high-temperature air-cooled TORY-IIA engineering test reactor. To determine the effluents released, and environmental dispersal of these effluents, air-sampling and micrometeorological network was constructed at the AEC Nevada Test Site. The network instrumentation provided the data needed to evaluate the radiological hazards associated with the downwind dispersal of fission products. The direct radiation from the reactor was also measured. The experimental data and their analysis are presented along with a description of the test site, sampling equipment, and analytical techniques used. (auth)

**11954** (NYO-10284) ULTRASONIC CLEANING OF ORGANIC MODERATED FUEL ELEMENTS. Bimonthly Progress Report No. 3, August 1–September 30, 1962. (Aeroprojects, Inc., West Chester, Penna.). Oct. 1962. Contract AT(30-1)-3002. 17p.

Investigations have continued into ultrasonic methods for removing from OMRE fuel plates the deposited film which interferes with heat transfer. Working with simulated films

pyrolytically and radiolytically deposited from new and used reactor coolant on small metal specimens, it was shown that ultrasonic activation in the flexural mode was preferable to proximity coupling. Ultrasonic cleaning of the simulant deposits was accomplished in Santowax OMP, the present coolant of choice, as well as in several other candidate coolants. Additional cleaning media were investigated. A few, notably dimethylformamide, dimethylacetamide, diethylacetamide, and 1,3-dimethylurea, appear to permit much faster cleaning than the coolant substances. Work is being directed toward the demonstration cleaning of individual fuel plates fouled in the reactor itself. To speed this laboratory-scale work to the geometry of the long, flat OMRE driver plates, a simply applied substitute coating is being used for acoustic studies. Ultimately, the work will include the cleaning of an intact fuel element containing an assembly of plates. (auth)

**11955** (ORNL-3372) GAS-COOLED REACTOR PROGRAM. Semiannual Progress Report for Period Ending September 30, 1962. (Oak Ridge National Lab., Tenn.). Feb. 1, 1963. Contract [W-7405-eng-26]. 476p.

Investigations carried out in support of the Experimental Gas-cooled Reactor included: performance analysis, structural studies, component development and testing, materials development, irradiation testing of components and materials, and development of experimental facilities. Design and development studies, system analyses, and determination of heat transfer anf fluid flow in packed sphere beds were carried out for the Pebble-Bed Reactor Experiment. Progress is also reported on investigations of fueled graphite and moderator materials, clad fuel development, design studies of advanced systems, experimental investigations of heat transfer and fluid flow, and development of facilities and equipment. (M.C.G.)

**11956** (TID-3573) FAILURE OF REACTOR FUELS. A Literature Search. Richard J. Smith, comp. (Division of Technical Information Extension, AEC). Nov. 1962. 17p.

One hundred and fifty-four references to unclassified report and journal literature generated from 1957 to December 1962 on specific studies of fuel failure are presented. The references are presented alphabetically by corporate author. (M.C.G.)

**11957** (TID-8200(7th Rev.)) NUCLEAR REACTORS BUILT, BEING BUILT, OR PLANNED IN THE UNITED STATES AS OF DECEMBER 31, 1962. (Division of Reactor Development, AEC). 23p.

Information is presented on five categories of reactors: civilian reactors, military reactors, production reactors, reactors for export, and critical assembly facilities. Within each category, the reactors are arranged into groups of power, experimental, and research reactors. (D.L.C.)

**11958** (TID-11601) DETERMINATION OF CONTROL ROD WORTH. EXPERIMENTAL GAS COOLED REACTOR. Physics Report No. 104. [E. R. Wagner] (Allis-Chalmers Mfg. Co. Atomic Energy Div., Washington, D. C.). June 23, 1959. For [Kaiser Engineers. Div. of Henry J. Kaiser Co., Oakland, Calif.]. Contract AT(10-1)-925. 15p.

A method for measuring the effect of the EGCR rods on $K_\infty$ in a cold core lattice with fuel enriched to 1.8% is described. (J.R.D.)

**11959** (TID-15779) CONTAMINATION AND DECONTAMINATION STUDIES RELATED TO BOILING WATER REACTORS. D. Grosvenor, W. Seefeldt, and S. Vogler (Argonne National Lab., Ill.). Mar. 1962. Contract W-31-109-eng-38. 23p. (UAC-6208)

A closed loop experiment simulating the fluid flow of a boiling reactor was conducted to study the spread of long-lived activity from fuel failure and its decontamination. The hot water was exposed to irradiated natural U metal, and the stainless steel loop was then cooled for decontamination studies. The loop water was found to contain $Cs^{131}$ with smaller amounts of $Zr^{95}$ and $I^{131}$, while in the steam $Ru^{103}$ was the predominant activity with smaller amounts of $Cs^{131}$, $Zr^{95}$, $Ce^{141}$, and $I^{131}$. A decontamination factor of ~1000 was observed in going from water to steam. Activity deposition on stainless steel strips was studied and used to calculate the radiation level from a steam line. The loop was decontaminated effectively with peroxide-carbonate-bicarbonate and oxalate-peroxide solutions. Laboratory studies were carried out on the decontamination of 304 stainless steel by $KMnO_4$-NaOH solution/ammonium citrate solution and oxalate-peroxide solution. The stability and corrosive effects of the decontaminating solutions are discussed briefly. (D.L.C.)

**11960** (TID-16142(Pt.I)) KINETICS OF LOW SOURCE REACTOR STARTUPS. PART I. H. Hurwitz, Jr. (General Electric Co. Research Lab., Schenectady, N. Y.), D. B. MacMillan, J. H. Smith, and M. L. Storm (Knolls Atomic Power Lab., Schenectady, N. Y.). June 1, 1962. Contract [W-31-109-eng-52]. 33p.

Statistical fluctuations of neutron populations in reactors are analyzed by means of an approximate theoretical model. Development of the model is given in detail; also included are extensive numerical results derived from its application to systems with time-dependent reactivity, namely, a reactor during start-up. The special relationships of fluctuations to safety considerations are discussed. (auth)

**11961** (TID-16142(Pt.II)) KINETICS OF LOW SOURCE REACTOR STARTUPS. PART II. H. Hurwitz, Jr. (General Electric Co. Research Lab., Schenectady, N. Y.); D. B. MacMillan, J. H. Smith, and M. L. Storm (Knolls Atomic Power Lab., Schenectady, N. Y.). June 1, 1962. Contract [W-31-109-eng-52]. 29p.

A computational technique is described for computation of the probability distribution of power level for a low source reactor startup. The technique uses a mathematical model, for the time-dependent probability distribution of neutron and precursor concentration, having finite neutron lifetime, one group of delayed neutron precursors, and no spatial dependence. Results obtained by the technique are given. (auth)

**11962** (TID-17574) CALCULATED EFFECTS OF NEUTRON RETHERMALIZATION IN $D_2O$ COOLANTS. Frank E. Driggers (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). [Jan. 1963]. Contract AT(07-2)-1. 13p.

Studies were made of neutron rethermalization in uranium and uranium oxide fueled, heavy water cooled and moderated lattices. The THERMOS code was used to calculate the spatial distribution of neutron spectra and of several cross sections of interest in two typical cells with cylindrical symmetry. The calculated changes of effective neutron temperature with coolant temperature for these lattices were relatively small. The neutron temperature increased 20 to 30°C when the coolant temperature changed from 90 to 215°C. (M.C.G.)

**11963** (TID-17738) PILE OSCILLATOR DETERMINATION OF CAPTURE TO FISSION RATIO. W. C. Redman (Argonne National Lab., Ill.). Sept. 21, 1962. Contract [W-31-109-eng-38]. 10p. (RED-EPM-102)

A method for the experimental determination of the capture-to-fission ratio (alpha) in low-flux reactors is

outlined. The procedure utilizes pile oscillator techniques but does not require an absolute determination of either the reactivity or the reactor power. A spontaneous fission source is used to establish the importance function for fission neutrons. Methods are suggested for the determination of the absolute absorption and fission rates required in the proposed procedure. The technique is applicable to both thermal and fast critical assemblies. (auth)

**11964** (TID-17815) CONTROL ROD CALIBRATIONS FOR JUGGERNAUT BY A DIGITAL METHOD. C. E. Cohn (Argonne National Lab., Ill.). Aug. 24, 1962. Contract W-31-109-eng-38. 40p. (RED-EPM-101)

A technique was developed which can obtain the complete worth curve of a control rod in one run. The run begins with the reactor critical and the rod to be measured fully out. Two neutron counters are placed at appropriate locations and connected to a special scaler chassis. This is connected to a digital printer, which records the accumulated counts and resets the scalers. With the system operating, the rod is run in. The resulting printer record is analyzed to yield reactivity as a function of rod position. The theory, equipment, method, and results are discussed. (M.C.G.)

**11965** (UNC-5008-I) INVESTIGATION OF WET STEAM AS A REACTOR COOLANT (CAN-2). VOLUME I. BEHAVIOR OF A FOG FLOW AS A COOLANT. Final Report. R. P. Stein, H. Firstenberg, S. Israel, M. Crane, and R. Hankel (United Nuclear Corp. Development Div., White Plains, N. Y.). Aug. 10, 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(30-1)-2828. 207p. (NYO-9844-I)

Theoretical and experimental studies were performed to enhance the understanding of the mechanism of heat transfer in vapor-liquid mixtures under fog flow conditions. Mass conservation was applied to an idealization of fog flow, involving simple representation of turbulent diffusion of droplets, and allowing for droplet coalescence and breakup. This application resulted in a general theory describing the behavior of a fog flow as a coolant. Use of the theory was illustrated by application to special simplified cases, in which liquid mass flow in a possible film at the wall is considered negligible. When application is made to cases with evaporation at the wall, the theory accounts for liquid transport to the wall by droplet diffusion and liquid carryover with the vapor away from the wall. The critical heat transfer condition occurs when the net flow of liquid toward the wall is insufficient to keep the wall wet. Comparison of theory with CISE burnout data and Ansaldo high pressure phase distribution data appears encouraging. A prediction that no critical heat transfer condition will be obtained when a characteristic dimensionless group is less than a certain value was in agreement with the CISE data. Interaction of a stream of 200-250 $\mu$ droplets with saturated steam under atmospheric pressure was studied using high speed still photography to test whether the distribution of droplets in a turbulent vapor stream can be described on the basis of a droplet diffusion model. The results of this study give evidence that droplets of this size are capable of rapidly assuming the velocity of the flowing stream, providing general confirmation to the hypothesis that the transport of droplets in a turbulent stream below a certain size may be described by a diffusion law. (auth)

**11966** (EURAEC-465) HYDRODYNAMIC INSTABILITIES LIMITING THE POWER OF BOILING WATER REACTORS. Quarterly Report No. 2, June 15 to September 15, 1962. (France. Commissariat à l'Energie Atomique. Centre d'Etudes Nucleaires, Grenoble). Oct. 1, 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 076-61-12RDF. 22p. A translation.

Previous tests carried out with a thin walled stainless steel channel (wall thickness 0.5 m/m) did not enable the oscillatory conditions to be reproduced even under identical conditions to those which resulted in instabilities with the aluminum tube of 1 mm wall thickness. The tests resumed with an aluminum channel confirmed that this anomaly was quite specific to the wall constitution (probably heat conduction effect). In addition, it was found that the pressure loss at the inlet valve brought on the oscillations at a lower temperature, with a constant piezometric load (probably the effect of the diminution of apparent velocity). Considerable overheating of the wall (several hundred degrees) was produced without instabilities, as soon as the pressure loss became large, or with low power (and low velocity). The measurements of pressure loss along channel n° 31 of the CF4 were analyzed and showed that the friction pressure loss was relatively high in relation to the usual correlations. The wall heating increased the friction pressure loss, but only slightly. The tests carried out in a horizontal channel of the visualization cell demonstrated the existence of periodic conditions. (auth)

**11967** (EURAEC-499) THEORETICAL AND TECHNICOLOGICAL STUDY OF NUCLEAR FUELS IN THE FORM OF COMPOSITE REFRACTORY PELLETS. Quarterly Report No. 3, July 1, 1962 to September 30, 1962. (Compagnie pour l'Étude et la Réalisation de Combustibles Atomiques, Bonneuil-sur-Marne, France). Work Performed under United States–Euratom Joint Research and Development Program. Contract 77-61-12RDF. 148p. A translation.

Includes Appendix: COMPOUND PELLETS. Period Covered: June 15 to September 1962. (Compagnie Industrielle des Combustibles Atomiques Frittés, Corbeville, par Orsay (Seine-et-Oise), France).

The methods of calculation perfected during the preceding quarter were applied numerically and have supplied the value of the coefficient of multiplication determined for 108 different configurations of the lattice and the fuel (new and cold). It appears that concentrations of fissionable material at the periphery of the pellets tend to reduce the anti-trap factor and lead to lower coefficients of multiplication than when uranium oxide and thoria are in homogeneous mixture. Results of long-term kinetic studies indicate that the reactivity variation during long irradiations will be more moderate in the composite fuel than in the homogeneous fuel. For a ratio of given thoria and rod radii and an average total enrichment, $K_\infty$ increases constantly with the radius of the rod throughout the interval studied (0.4 to 1 cm). The aim of composite fuel development is to reduce the temperature range at constant specific power in the pellets or conversely to increase the specific power while maintaining tolerable thermal gradients. Means of reconciling the opposed tendencies is achieved in an arrangement by which at constant power the division of the fuel is reduced (hence its price) and the neutronic economy is improved by increasing the diameter of the rod. At constant dimensions, the composite arrangement makes it possible to increase the linear power without raising the temperature ranges. (J.R.D.)

**11968** STRIKING A BALANCE IN URANIUM FUELS. N. L. Franklin (United Kingdom Atomic Energy Authority, Risley, Eng.). Atom, No. 75, 15-18(Jan. 1963).

The potential of nuclear power is reviewed. Discussion

is given on fuel design, economic balance, and the efforts in the field of nuclear power by both the British and the United States. The selection of the type of fuel for a series of nuclear power stations involves striking a balance between increasing the cost of the fuel and reducing the capital cost of the reactor. (P.C.H.)

**11969** MODIFICATION OF THE COOLING EFFICIENCY OF GAS-COOLED REACTORS BY THE TEMPERATURE DEPENDENCE OF THE GAS PROPERTIES, BURNUP, AND CONTROL. H. Benzler. Atomkernenergie, 7: 345-9(Oct. 1962). (In German)

The cooling efficiency of gas cooled reactor channels was derived in former publications under the assumption that the thermodynamic and transport properties of the cooling gas were not markedly dependent on gas temperature. This limitation is now abandoned and new general equations are presented. A comparison between both methods of calculation is made. Furthermore, the influence of fuel burnup and reactivity control on cooling efficiency is investigated. (auth)

**11970** FAST NEUTRONS AND FAST REACTORS. Wilhelm Sahl. Euratom Bull., No. 4, 2-9(1962). (In English)

An outline is given of the principle, design, fuels, control and safety, and development of fast reactors. The general characteristics of fast and thermal reactors are compared. (T.F.H.)

**11971** GEOGRAPHICAL DISTRIBUTION OF WORLD'S 518 NUCLEAR REACTORS. Nucl. Energy, 25(Jan. 1963).

Of the 518 reactors listed, 381 were operable and 137 were under construction. The list containing the number of reactors in each country was obtained from various sources. (C.E.S.)

**11972** A GENERALIZED VARIATIONAL METHOD FOR REACTOR ANALYSIS. Alfred L. Mowery, Jr. and Raymond L. Murray (North Carolina State Coll., Raleigh). Nucl. Sci. Eng., 14: 401-13(Dec. 1962).

A technique designated as the generalized variational method (GVM) is described. The analysis is based on the variational approach and is an outgrowth of investigations in the hypercircle method. In essence, the GVM consists of considering the trial functions that appear symmetrically (quadratically) in a positive-semidefinite variational principle as independent functions. A proposition is proved to demonstrate generally that the approximate eigenvalue obtained from the GVM is at least as accurate as the geometric average of the associated approximate eigenvalues. Also, a conjecture is proposed that the accuracy of the generalized variational eigenvalue is comparable to that of a variational result employing a trial function incorporating the dimensionality of both associated trial functions. The application of the GVM to the perturbation-variational method yields results that establish the method. The generalized method completes the perturbation-variational method by providing the even-order approximate results. For illustration, the GVM is employed to solve a bare reactor with a grey control sheet. Using Rayleigh-Ritz optimized cosine series and optimized pyramid functions as associated solutions, the generalized variational eigenvalue accuracy indicates the effective combination of the dimensionalities of the associated trial functions. (auth)

**11973** HAZARDS EVALUATION FOR THE NEW REACTORS SITED AT NUCLEAR RESEARCH CENTRE "ŚWIERK." Wacław Frankowski (Inst. of Nuclear Research, Polish Academy of Sciences, Warsaw). Nukleonika, 7: 599-610(1962). (In English)

The hazard evaluation for a zero power reactor Anna and the second Polish experimental reactor is presented. The analysis shows the controlled containment with 99% iodine filtration as a satisfactory protective measure in given siting of the second Polish experimental reactor. The reactor Anna was found to be safe enough to be built in an ordinary building. (P.C.H.)

**11974** APPROXIMATE DETERMINATION OF FLOW AND TEMPERATURE FIELD IN PEBBLE-BED GAS-COOLED REACTOR. Bohdan Krajewski (Inst. of Nuclear Research, Polish Academy of Sciences, Warsaw). Nukleonika, 7: 611-22(1962). (In Polish)

Discussion is given on the determination of the flow and temperature field in gas flowing through packed beds. Analyses are presented for the cases when the thermal conductivity of gas is neglected and the total pressure is assumed to be constant in the considered region. The problem can be reduced to a partial differential equation with given boundary conditions. Bearing in mind that the considered differential equation corresponds to a variational problem, the Ritz method is used for a numerical solution. (auth)

**11975** RECENT DEVELOPMENTS IN THE THEORY AND TECHNOLOGY OF CHAIN REACTORS. Lawrence Dresner and Alvin M. Weinberg (Oak Ridge National Lab., Tenn.). Rev. Mod. Phys., 34: 747-65(Oct. 1962).

The present status of a few of the parts of the theory and the technology of chain reactors which are particularly associated with Wigner's work is described. The theory of four topics is reviewed: the spectrum of the Boltzmann equation, neutron thermalization, thermal utilization, and resonance absorption. (W.D.M.)

**11976** DEVELOPMENT AND SELECTION OF A TYPE OF ATOMIC POWER PLANT WITH PARTICULAR REFERENCE TO THE POSSIBILITIES OF MANUFACTURING THE NECESSARY EQUIPMENT DOMESTICALLY. Josif Levi. Tehnika (Belgrade), No. 1, 77-84(1962).

Problems relating to the construction of a 100-150 Mw atomic power plant in Yugoslavia with particular reference to the possibilities of domestically manufacturing the required equipment are discussed. A short summary of scientific and technological achievements in constructing atomic power plants in Western countries is given. An atomic power plant with a graphite moderator and gas or heavy water as a coolant is considered the most suitable type to be built in Yugoslavia. An analysis of the capabilities of Yugoslav industrial enterprises considered adequate to produce the simplest equipment required for such a plant shows that one of the main problems will consist in constructing the fuel supply and manipulating equipment. An additional and serious problem is the lack of trained personnel. (P.C.H.)

## Power Reactors

*Refer also to abstract 11133.*

**11977** (ACNP-62028) PATHFINDER ATOMIC POWER PLANT SINGLE ROD BURNOUT HEAT FLUX TESTS. Summary Report. K. F. Neusen and G. J. Kangas (Allis-Chalmers Mfg. Co. Atomic Energy Div., Milwaukee). Dec. 21, 1962. For Northern States Power Co., Minneapolis and Central Utilities Atomic Power Associates. Contract AT(11-1)-589. 41p.

Results of an investigation to obtain burnout data for use in design of the Pathfinder boiler core are presented. It was found that burnout relations developed for round and rectangular channels are not applicable to single-rod burnout at 600 psia. The data taken in the tests do not permit

isolation of mass flow and inlet subcooling effects on burnout heat flux. A design equation is included which yields conservative burnout predictions for the Pathfinder operating conditions. (J.R.D.)

**11978** (AGN-TM-399) ARMY GAS-COOLED REACTOR SYSTEMS PROGRAM. PRELIMINARY SPECTRAL ANALYSIS OF GCRE AND ML-1 REACTOR OPERATION. J. H. Dorsey (Aerojet-General Nucleonics, San Ramon, Calif.). Dec. 1962. Contract AT(10-1)-880. 25p.

The analytical methods employed in a preliminary spectral analysis of the operation of the GCRE and ML-1 reactors to determine the presence, or absence, of underlying periodicity are described. The probable errors assigned to the results are discussed. The analysis concludes that no statistically significant periodicities existed in the reactor data within the limits of resolution of the analytical techniques. (auth)

**11979** (DP-805) HEAVY WATER MODERATED POWER REACTORS. Progress Report, November 1962. L. Isakoff and R. R. Hood, comps. (Du Pont de Nemours (E. I.) & Co. Atomic Energy Div., Wilmington, Del.). Dec. 1962. Contract AT(07-2)-1. 59p.

The Heavy Water Components Test Reactor (HWCTR) was operated intermittently at a maximum power of about 35 Mw for irradiation of test fuel assemblies of various types. Near the end of November, a cladding failure occurred in an assembly of two Zircaloy-clad tubes of unalloyed uranium. The reactor was scrammed without incident, and the activity in the primary coolant system decreased from 0.026 microcurie/ml 16 hours after the scram to 0.0037 microcurie/ml 5 days after the scram. Hardness measurements at elevated temperature indicate that the addition of about 200 ppm of silicon to U–350 ppm Fe–900 ppm Al might increase the resistance of the latter to swelling during irradiation. Resonance integrals and self-shielding factors were measured for a variety of foil materials that are frequently used in experimental lattice studies. Experimental data were obtained on heat transfer burnout for forced flow of subcooled water in annuli at pressures of 500 to 1000 psi. (auth)

**11980** (EURAEC-414) HEAT TRANSFER AND STABILITY STUDIES IN BOILING WATER REACTORS. Quarterly Progress Report No. 6, April 1, 1962–July 1, 1962. (Eindhoven, Netherlands. Technische Hogeschool). July 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 032-60-11-RDH. 42p.

Changes made in the boiling loop are reported. A subcooler circuit was connected to the downcomer providing a control on the inlet temperature to the riser. This circuit was especially designed for a low pressure drop. The subcooler power can be adjusted by controlling the water flow through four spirals installed in the circuit. Fine control is obtained by a preheater. This preheater gave some difficulties caused by a change in isolation resistance between the heating wire and the sheath of the heating coil. About 250 kw can be dissipated in the subcooler under conditions of natural circulation, giving a subcooling temperature of about 30°C at the inlet of the riser. A closer control of the secondary cooling water to the condenser, a remote level gage and a fast power control were installed. The void fraction method using scintillation counters was developed further. Some experiments were carried out regarding cooling, influence of magnetic fields and collimation on count rate. The stabilization of the amplification by the photomultiplier worked satisfactorily. New insulated thermocouples were installed for differential temperature measurements. It appeared, that the calibration is dependent on the value of the insulation resistance. A burn-out detector operating on a signal from a Wheatstone bridge was developed and installed. The study of boiling noise and development of theoretical models was continued. Information is also given regarding the burn-out and instability experiments carried out on a seven cluster heating element. During the burn-out detector development it was shown that the form of the hot patch has a large influence on the burn-out flux. A sharp hot patch has a significantly lower burn-out flux than a shaped one for the same operating conditions. In some experiments the out-of-balance signal from the burn-out detector was recorded on a Visicorder. Periodic oscillations were observed on the trace at about the natural hydraulic frequency. These oscillations were tentatively identified with hydraulic instability. (auth)

**11981** (GA-2630) CARBON TRANSPORT AND CORROSION IN HIGH-TEMPERATURE GAS-COOLED REACTORS. L. R. Zumwalt, R. D. Burnette, and A. B. Riedinger (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Apr. 12, 1962. Contract AT(04-3)-314. 44p.

It is noted that in high-temperature He-cooled graphite reactors, sufficiently high levels of gaseous impurities can lead to transport and corrosion effects. The possible effects of these reactions in graphite-moderated reactors designed to operate at a He-coolant pressure of a about 20 atm. were investigated. Results are included on C transport, steam-graphite reactions, and deposition of C on surfaces. (J.R.D.)

**11982** (GEMP-175) 630A MARITIME NUCLEAR STEAM GENERATOR. Progress Report No. 4. (General Electric Co. Flight Propulsion Lab. Dept., Cincinnati). Jan. 31, 1963. Contract AT(40-1)-2847. 95p.

Studies showed that four feedwater heaters in cycle give the highest efficiency, but the efficiency is only 0.6 of an efficiency point lower with only one heater. Aftercooling studies showed that the maximum temperature, with a sudden loss in primary cooling, a 1-second scram delay, and a 3-second delay for the aftercooling flow to reach 7.5 lb/sec, would be 1845°F. A study was completed on reducing the length of the reactor vessel by 20.5 inches. This could reduce the system weight by 18 tons. Measurement of a scrammed, flooded cell showed a lower reactivity than a dry cell without the rod inserted. Additional boron worth measurements are required to establish the cold clean reactivity of the critical assembly. The lowest value indicated is about 10.5 per cent $\Delta k/k$. Studies to position the nuclear sensors in the front shield plug are in progress. This location will provide monitoring of the reactor at all times and permit servicing of the sensors without disturbing other systems. A modified side shield, which would serve as a total containment vessel is being studied. This concept will provide shielding even in the event of fission product release from both the fuel and the pressure vessel. With this "shielded-containment" concept, the pressure vessel will operate at temperatures close to those of the lower head, thus reducing thermal stresses in these components. The coil for the two-tube boiler test was received; specified fabrication tolerances were exceeded. Studies were made to determine the effect of only shim insert, without period scram, in the intermediate power range. The power levels reached were not excessive, which indicates that it may be possible to bypass period scram at low powers where electrical noise is troublesome. Calculations indicate that the scram time for the first 5-inch insertion of the rods is only 5 per cent

longer in water than air. An order was placed for the fabrication and testing of the blower seal. The ORF-3 high burnup test has accumulated 1750 hours at 1450°F, which is equivalent to about 12,000 hours of 630A operation. Thermal cycle specimen EB-6 appeared to be in good condition after 5615 hours at 1600°F and 44 cycles to room temperature. The shakedown MTR sample 3-F-1 appeared to be in satisfactory condition after 591 hours at 1460°F. This sample will be inspected and, if no problems are found, sample 3-F-2 will be inserted for the long-time burnup test. Creep test of fuel sheets have reached 6000 hours at temperatures ranging from 1300° to 1600°F and stresses of 300 and 600 psi. Maximum elongation recorded is 0.3 per cent. Work is underway on the preparation of a preliminary safety report. All required operations are being studied and various accidents are being evaluated. Preliminary procedures, equipment, and facilities for handling maintenance operations are being established. The critical experiment reached criticality November 15, 1962, and various measurements such as rod worths, power distributions, boron worths, and cell flooding have been made. (auth)

**11983** (IDO-19311) FINAL REPORT OF SL-1 RECOVERY OPERATION, MAY 1961 THRU JULY 1962. (General Electric Co. Aircraft Nuclear Propulsion Dept., Idaho Falls, Idaho). July 27, 1962. Contract AT(10-1)-1095. (TM-62-7-704). 310p.

In May, 1961, it was determined no renewed nuclear reaction in the SL-1 pressure vessel was possible as long as water was excluded. It was therefore possible to proceed with the final phase of the SL-1 recovery. This work consisted of moving the pressure vessel and core to the Hot Shop at the north end of the National Reactor Testing Station, dissecting and analyzing the reactor and its components, cutting up and burying the reactor building, and decontaminating the rest of the SL-1 area. These things were accomplished by the General Electric Company between May 1961 and July 1962. It was determined that the central control rod was bound in its shroud at a position corresponding to 20-inch withdrawal. Analysis of the pertinent data showed that the amount of reactivity associated with this rod position, inserted at a rate compatible with manual withdrawal of the rod, can explain the significant evidence which was collected. No other means of withdrawing the rod was found to be in accordance with the evidence. It was found that the relatively low yield (130 Mw-sec) nuclear excursion produced a water hammer with pressures up to 10,000 psi, which, in turn, caused the pressure vessel to rise some 9 feet in the air. (auth)

**11984** (LAMS-2835) QUARTERLY STATUS REPORT ON ULTRA HIGH TEMPERATURE REACTOR EXPERIMENT (UHTREX) FOR PERIOD ENDING DECEMBER 20, 1962. (Los Alamos Scientific Lab., N. Mex.). Jan. 1963. Contract W-7405-eng-36. 20p.

Pressure tests of the reactor vessel showed that stresses were within allowable limits for the design pressure of 550 psig. Tests of the fuel loading mechanism are also reported in which 300,000 cycles were completed. Results of an investigation of core corrosion damage led to the conclusion that for prolonged operation of a graphite reactor in the ultrahigh-temperature range, the average $CO_2$ level must be limited to approximately 1 ppm. Developmental work on the coolant system is reported, and results of an analysis of the reactor and cooling system using an IBM 7090 program are discussed. Tests of the gas cleanup system are reported in which CuO was successfully used. Calculations concerning shielding showed that an extra 2 in. thickness of Pb should be added to the inside face between the water panels and the concrete to reduce the temperature gradient and the associated tensile stress below 1000 psi in the concrete walls. It is noted that the reactor facility was about 14% complete at the end of the reporting period. (J.R.D.)

**11985** (MND-M3A-2496(Vol.I)(Add.)) PM-3A NUCLEAR POWER PLANT HAZARDS SUMMARY REPORT CORRECTIONS FOR AS-BUILT CONDITIONS. W. C. Hall and E. O'Farrell (Martin-Marietta Corp. Aerospace Div., Baltimore). Dec. 1962. Contract [AT(30-1)-2700]. 68p.

Corrections for certain design data and construction and operating details are presented for the PM-3A nuclear power plant as given in report MND-M3A-2496. The corrections, which evolved as a result of tests, are presented in the order of their appearance in the basic report. (J.R.D.)

**11986** (NAA-SR-6307) THE SNAP II POWER CONVERSION SYSTEM TOPICAL REPORT NO. 15. CRU DESIGN AND DEVELOPMENT. (TAPCO. Div. of Thompson Ramo Wooldridge Inc., Cleveland). July 1961. For Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif. Contract AT-11-1-GEN-8, Subcontract N 843 FS-101221. 103p. (TRW-ER-4108)

SNAP II is the designation for a 3-kw nuclear auxiliary power unit to be used in a satellite vehicle. This system consists of a reactor heat source, a mercury Rankine engine and an alternator. The alternator, mercury pump, turbine, and reactor coolant pump are mounted on a common shaft supported by mercury lubricated bearings. Design details and test results concerning the combined rotating unit (CRU) development are described. (auth)

**11987** (ORNL-TM-476) ANALOG COMPUTER CALCULATIONS FOR THE LOSS-OF-POWER INCIDENT IN THE EGCR. C. S. Walker (Oak Ridge National Lab., Tenn.). Feb. 5, 1962. Contract [W-7405-eng-26]. 62p.

A loss of reactor coolant flow, such as that brought about by a loss of electrical power in the plant, could create higher than normal temperatures in the EGCR. The reactor outlet gas and fuel element temperatures were therefore determined during the first 4 to 5 min after the start of the blower coastdown. The investigation was carried out as parametric study to determine the sensitivity of the reactor temperatures to variations in blower coastdown rate, afterheat generation rate, $UO_2$ thermal conductivity, reactor scram signal setting, reactor gas inlet temperature, and initial power level. The blower coast down rate was found to have a considerable effect on the temperatures for the range of variations investigated. It was found that a blower coastdown from an initial plant power level of 20% of full power could create temperatures as high as those attained by a blower coastdown from the full power case. (auth)

**11988** (PWAC-100) SUPERCRITICAL WATER REACTOR SHIELD DESIGN PROCEDURE. C. F. deGanahl, H. Woodsum, and H. V. Garabedian (Pratt and Whitney Aircraft Div., United Aircraft Corp., Hartford, Conn.). June 1, 1954. Contract [AT(11-1)-229]. 59p.

Information concerning the assumptions, data, and methods used to estimate the SCWR shield weights of the PWAC-88 reactor system is presented. Information is included on divided shields, representative of what might be used for bomber aircraft, and quasi-unit shields designed for a specific configuration of logistics carrier. Numerical recipes for the two types of shield from which the calculations can be precisely duplicated, are given and a definition of the

reasoning behind the computing recipes is included. The report was written for the reader who is thoroughly familiar with the previous SCWR shield work, and only those points which involve recent changes are given detailed explanation. (auth)

**11989** (TID-11604) PRESSURE DROP EXPERIMENTS ON A PROPOSED FUEL ASSEMBLY FOR THE EXPERIMENTAL GAS COOLED REACTOR. SECTION I OF FUEL-ASSEMBLY HEAT TRANSFER AND CHANNEL PRESSURE-DROP EXPERIMENT FOR THE EGCR RESEARCH AND DEVELOPMENT PROGRAM. C. L. Beaudoin and R. M. Higgins (Allis-Chalmers Mfg. Co. Atomic Energy Div., Washington, D. C.). Jan. 20, 1960. For Kaiser Engineers. Div. of Henry J. Kaiser Co., Oakland, Calif. Contract AT (10-1)-925. 83p. (RD-0007)

Pressure drop data are presented for the EGCR seven rod fuel assembly. The effects of fuel assembly sleeve ID, location of the outer six rods of the seven fuel rod cluster, and the addition of helical finned spacers at the midpoint of each of the seven fuel rods, on pressure drop are discussed. The pressure drop data were obtained to verify preliminary design assumptions and to provide a basis for the detailed design of the EGCR reactor blower. Curves of Moody friction factors over a Reynolds Number range from 20,000 to 90,000 are included. Equations for friction factors over selected ranges of Reynolds Numbers are also given. The test procedure and set-up are also described. (auth)

**11990** (UCRL-5484(Del.)) TORY II-A—A NUCLEAR RAMJET TEST REACTOR. James W. Hadley, ed. (California. Univ., Livermore. Lawrence Radiation Lab.). Nov. 4, 1959. Contract W-7405-eng-48. 295p.

The design of Tory II-A is essentially complete and construction of the reactor and of its test facility is in progress. Test operation of the reactor is scheduled at a total power of 160 megawatts, with 800 pounds of air per second passing through the core and emerging at 2000°F. The core, 3 ft in dia and $4\frac{1}{2}$ ft long, will be composed of bundled ceramic tubes whose central holes will provide continuous air passages from end to end of a homogeneous mixture of $UO_2$ fuel and BeO moderator, compacted and sintered to achieve high strength and density. Surrounding the core will be a thick graphite reflector containing moveable B-loaded nuclear control elements. The entire reactor, together with control actuators, a duct to bring coolant air up to and away from the core, and other auxiliaries, will be mounted on a railroad flatcar for convenient transportation between assembly-disassembly shops and the test point. A group of steel tanks will store 100,000 pounds of air, enough to cool the reactor at full power for at least a minute, with sufficient reserve for startup and shutdown phases. In addition, blowers will furnish a continuous supply of air at a much lower rate for low-power operation and for protracted cooling after a full-power run. Operation of the reactor will be controlled from a building about 2 miles distant from the test point. In addition to information on inlet air conditions and on neutron flux level which will be necessary for reactor control, very extensive data on air and structure temperatures throughout the reactor, on air pressure distribution, and on strain and vibration in the reactor will be transmitted to the control building for display and recording. A heavily shielded disassembly building, fitted with remote-handling equipment, will provide for inspection and repair during the course of test operations, as well as dismantling of the reactor after completion of tests, to permit thorough examination of components. (auth)

**11991** (WAPD-PWR-TE-81) SHIPPINGPORT PWR-1 SEED 2 PHYSICS TEST RESULTS FROM 50 EFPH TO 3600 EFPH. Test Evaluation. J. H. Leonard and G. H. Saito (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). Feb. 10, 1961. Contract [AT-11-1-Gen-14]. 35p.

Comparisons are made between the test results and calculated values to evaluate the computational methods. It was concluded that no pronounced weaknesses in the method is indicated except in rod worth calculations. It appears that the calculations are reliable in prediciting changes in core composition and reactivity during Seed 2 life. (J.R.D.)

**11992** (WAPD-PWR-TE-93) FLOW DISTRIBUTION ACROSS THE CORE, SECTION II. Core 1, Seed 2. Test Evaluation (T-550097) DLCS-1820202. M. G. Friedman (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). Mar. 6, 1961. Contract [AT-11-1-GEN-14]. 14p.

Tests were conducted to determine the flow mixing characteristics of the lower plenum and flow baffle of the PWR reactor vessel. Results substantiate the extent of coolant mixing in the lower plenum chamber as predicted by a Battelle quarter-scale air flow model of PWR. Mixing was found to be slight and confined mainly to the quadrant adjacent to the loop in question. (J.R.D.)

**11993** (WAPD-T-1369(Rev.)) MEASUREMENT AND CALCULATION OF THE POWER DISTRIBUTION IN THE PWR-2 MOCK-UP. W. Baer, R. P. Christman, R. F. Valentine, and K. P. Barr (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). June 1962. Contract AT(11-1)-Gen-14. 17p.

Experiments to measure gross and local power distributions in the Shippingport Pressurized Water Reactor Core 2 Mock-up have been performed and compared with a nuclear design model developed for this core. The results show a consistent deviation over a wide range of core conditions and thus permit adjustment of calculation when the power capability of the core is evaluated. (auth)

**11994** (WAPD-T-1370) CRITICALITY PREDICTIONS OF THE PWR-2 DESIGN MODEL. R. F. Valentine and R. P. Christman (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). Sept. 1961. Revised Jan. 1962. Contract AT(11-1)-Gen-14. 25p.

The achievement of the design objectives of PWR-2 is dependent in large part on the ability of the nuclear design calculational technique to predict core behavior. The model was used to calculate the critical condition of many cores of different geometry, temperature, poison loadings and fuel loadings which were experimentally tested in both high temperature and ambient temperature facilities. The average calculated critical eigenvalue was 1.004 with a standard deviation of 0.003. While in actual value this represents a very good prediction of the critical condition, the really significant factor is that all of the calculations fall in a relatively narrow range. Regardless of the core condition under study, the calculations using the nuclear design model produced a critical eigenvalue which was essentially constant when the uncertainties in the measured axial bucklings, which are reflected in the eigenvalues, are considered. Thus, a fixed eigenvalue bias may be applied to criticality calculations for the design PWR-2 core with reasonable expectations that the result will be correct. (auth)

**11995** (WAPD-T-1371(Rev.)) BORON CAPTURE FRACTION MEASUREMENTS IN PWR-2 GEOMETRY. W. Baer (Westinghouse Electric Corp. Bettis Atomic

Power Lab., Pittsburgh). June 1962. Contract AT (11-1)-Gen-14. 15p.

Measurements of the ratio of boron captures to $U^{235}$ fissions in a seed fuel subassembly which mocks up the Shippingport PWR-2 design were performed for two different boron poison elements and at two core temperatures. The results were compared with calculation, and the agreement is considered satisfactory. (auth)

**11996** (WCAP-4125) CVTR PROJECT, CAROLINAS VIRGINIA NUCLEAR POWER ASSOCIATES, INC. MONTHLY PROGRESS REPORT, MAY 1962. (Westinghouse Electric Corp. Atomic Power Div., Pittsburgh). Contract AT(30-1)-2289. 17p.

Progress is reported in nuclear design and irradiation experiments and analysis. Information is included concerning project administration and status of reports being prepared on pressure tube development and fuel development. Other information is included on irradiation experiments and post-construction research and development. (J.R.D.)

**11997** (WCAP-4131) CVTR PROJECT, CAROLINAS VIRGINIA NUCLEAR POWER ASSOCIATES, INC. MONTHLY PROGRESS REPORT, NOVEMBER 1962. (Westinghouse Electric Corp. Atomic Power Div., Pittsburgh). Contract AT(30-1)-2289. 7p.

Data and information are included concerning project administration in the areas of report preparation and post-construction research and development. Information is also included concerning plant nuclear evaluation, ultrasonic pressure tube analysis, and metallurgical examination of CVTR components. (J.R.D.)

**11998** (AEC-tr-5484) THE GAS-COOLED HIGH-TEMPERATURE REACTOR OF THE BBC-KRUPP GROUP. Rudolf Schulten, Erich Jantsch, Hermann Wundt, Oskar Machnig, Andreas Setzwein, and Wlater Stuermer (Arbeitsgemeinschaft BBC-Krupp, Mannheim, Germany). Translated for Oak Ridge National Lab., Tenn. [1959]. 26p.

The Jülich atomic power plant in Western Germany for which a contract was let in August 1959 will contain a new high-temperature reactor. The operation of this reactor developed by the BBC-Krupp Group is explained, and a description is given of the design of the thermal action of the power plant. (auth)

**11999** (AEC-tr-5610) PERMISSIBLE PERFORMANCE LIMITS OF THE FUEL ELEMENTS IN GRAPHITE–$CO_2$ REACTORS. A. Gauvenet and M. Salesse (France. Commissariat à l'Energie Atomique. Centre d'Etudes Nucléaires, Saclay). Translated for Oak Ridge National Lab., Tenn. from Report DM/62-299. Sept. 13, 1962. 23p.

An analysis is made of the factors which limit the performance of fuel elements in graphite-moderated, $CO_2$-cooled reactors: possible container rupture, magnesium cladding which must be used below 470°C, uranium rods which must be used below 600°C, and burnup which in present-day reactors is limited to 3500 Mwd/t. It is shown that the fuel element performance can be increased by increasing the specific power, increasing the burnup, and using fuel bundles or fuel tubes with bilateral cooling, and that such increases are technically feasible. Power cost graphs are given. (D.L.C.)

**12000** ECONOMIC CONSIDERATIONS IN THE LAY-OUT OF STEAM GENERATORS FOR GAS-COOLED REACTORS. W. E. Bausa and M. Pfeifer (Deutschen Babcock & Wilcox Dampfkesselwerke A. G., Oberhausen, Ger.). Atomkernenergie, 7: 350-8(Oct. 1962). (In German)

From the thermodynamic optimization of the reactor and the steam turbine process, the steam generator for which the cost function is a minimum is determined. With certain assumptions and under consideration of the essential parameters, which determine the design of the steam generator—e.g., tube data, temperature differences, circulator power, utilization factor, and prices—a first approximation of an optimal lay-out range of the steam generator is given. The approximation is sufficient for a project stage. The considerations are referred to a single-pressure steam process and are extended for the single-pressure steam process with reheating. (auth)

**12001** ECONOMIC ASPECTS OF A GAS-COOLED, HEAVY WATER MODERATED, NATURAL URANIUM REACTOR. N. H. Schludi. Atomwirtschaft, 7: 548-52(Nov. 1962). (In German)

Although technical considerations determine reactor construction in the case of other reactor types, economic factors are of primary importance for heavy water, natural uranium reactors. If the number of days of operating at full load is large, then the economic optimum lies with a reactor having a high heavy water charge. On the other hand with a restricted load factor, the fixed costs must be reduced as far as possible. A heavy water high-temperature reactor cooled with $CO_2$ was considered in order to determine the economic factors. The reactor studied had a capacity of 100 Mw(e) with an efficiency of 30%. It was concluded that such a reactor can be economically justified if it can be operated as a basic load station and its specific plant costs do not exceed 750 DM per installed kwe (without the heavy water and fuel loads). (auth)

**12002** MAGNETOHYDRODYNAMIC POWER GENERATION BY NON-THERMAL IONIZATION AND ITS USE IN NUCLEAR REACTORS. E. J. Sternglass, T. C. Tsu, G. L. Griffith, and J. H. Wright (Westinghouse Electric Corp., Pittsburgh). Engrs'. Dig., 23: No. 11, 74-9 (Nov. 1962).

Ionization of gases by non-thermal means for magnetohydrodynamic power generation is discussed. Both ionization by fission-product radiation and by electron-beam injection are described. A thermodynamic cycle to incorporate non-thermal ionization is outlined. The designs of a nuclear reactor and magnetohydrodynamics generator for a power plant are discussed. Studies indicated that non-thermal ionization by means of fission products dispersed in the gas is at best marginal, but that the use of injected electron beams appears to be feasible for closed-cycle systems employing rare gases as working media. (M.C.G.)

**12003** SODIUM-COOLED REACTORS: THE HALLAM POWER PLANT (HNPF). Fred C. Gronemeyer. Ind. At., 6: No. 9-10, 79-88(1962). (In French)

A general description is given of the 75 Mw(e) sodium-graphite reactor constructed at Hallam. The startup program has begun, and the low-power operation is scheduled for the end of 1962. This first industrial realization of a nuclear power plant using superheated steam represents an important step in the construction of truly economic power plants. (tr-auth)

**12004** STUDY OF THE FEEDBACK-REACTOR DYNAMICS BY MEANS OF ELECTRIC MODELLING. I. I. Sidorova. Inzh.-Fiz. Zh., Akad. Nauk Belorussk. SSR, 5: No. 10, 53-7(Oct. 1962). (In Russian)

When designing nuclear power plants, all possible inner negative feedbacks of various reactor elements should be taken into account, and stability criteria should be studied

even at the outset of designing. This necessity is caused by self-oscillations or resonance of the amplitude-versus-frequency response characteristics of some types of reactors with negative feedback. In designing automatic control systems with negative feedback, dangerous resonance frequencies should be determined. (auth)

**12005** THE DRAGON IRRADIATION PROGRAMME. R. A. Saunders. Nucl. Eng., 8: 15-19(Jan. 1963).

Irradiation programs were carried out to establish that the materials selected for the Dragon Reactor will maintain satisfactory operating characteristics for the time expected of them. The following experiments are described and the information obtained in them presented: pressure vessel steel irradiation; graphite irradiation; fuel capsule rig testing; fuel element replacement rig testing; evaluation of small-scale high-power-density samples; and studies with DIDO loop, fission-product-emission loops, Pluto loop, and in-pile carbon transport loop. (M.C.G.)

**12006** MITCHELL'S SCLMR—DESIGN OF COMPETITIVE MARINE REACTOR. H. J. Coles. Nucl. Eng., 8: 58-63(Feb. 1963).

The design of the Steam Cooled Light Water Moderated Reactor (SCLMR) is discussed. Core coolant flow, moderator circuit, turbo circulators, secondary steam generators, reactor containment, core physics, moderator purification and feed systems, air conditioning system, control and instrumentation, control of primary steam cycle, design safety principles, and development potential are described. Drawings are included. (M.C.G.)

**12007** EGCR OPERATIONAL REFUELLING. Harold D. Young. Nucl. Eng., 8: 64-9(Feb. 1963).

The EGCR charge machine for operational refueling is described. The charge machine is located below the reactor, and the advantages of bottom charging are outlined. The environment, components, sequence, control, time, design problems, reliability, prototype testing maintenance, rehearsal, decontamination, and hazards are discussed. Drawings are included. (M.C.G.)

**12008** MEAN-SQUARE ERROR MINIMIZATION OF BOILING REACTOR NOISE. Lynn E. Weaver and Kenneth R. Katsma (Univ. of Arizona, Tucson). Nucl. Sci. Eng., 14: 380-3(Dec. 1962).

An analytical approach is taken to develop a model of an optimum linear control system for a linearized approximation to a boiling water reactor. The optimization criterion used is the minimization of the mean-square error of the random fluctuation in the output variable resulting from boiling voids. In optimizing the system an acceleration constraint is placed on the control rod drive mechanism. The mean-square error of the output variable is calculated for various constraint levels. Results show that a considerable reduction in the mean-square error of the reactor output can be realized through external control. (auth)

**12009** POWER REACTOR TECHNOLOGY. Volume 6, No. 1. Walter H. Zinn (General Nuclear Engineering Corp., Dunedin, Fla.). Dec. 1962. $0.55 (GPO) (domestic), $0.70 (GPO) (foreign). (One of the Technical Progress Reviews prepared quarterly for the Division of Technical Information, USAEC).

Eleven papers of a review type are presented on topics in the field of power reactor research, development, applications, design practice, and operating experience. Separate abstracts were prepared for all the papers. (D.L.C.)

**12010** ECONOMICS: COST EVALUATION GUIDE. p.1-2 of "Power Reactor Technology. Volume 6, No. 1."

The handbook "Guide to Nuclear Power Cost Evaluation" is described briefly. The uses and ranges of the guide are discussed. (D.L.C.)

**12011** REACTOR PHYSICS. p.3-14 of "Power Reactor Technology. Volume 6, No. 1."

A review is presented of recent experimental work on critical and exponential experiments, reactor physics constants, and neutron thermalization. (D.L.C.)

**12012** HEAT TRANSFER. p.15-25 of "Power Reactor Technology. Volume 6, No. 1."

A review is presented of some of the papers presented at the Fifth National Heat Transfer Conference and Exhibit and of other articles dealing with heat transfer in the nuclear engineering field. Some of the topics treated are subcooled nucleate boiling in forced convection, boiling burnout in rod bundles, burnout correlation, pool boiling, sodium pool boiling, swirl flow, gas-solid mixtures, and analysis of multipass cores. (D.L.C.)

**12013** FUEL ELEMENTS: FABRICATION BY POWDER COMPACTION. p.26-37 of "Power Reactor Technology. Volume 6, No. 1."

A summary is presented of the information available on the fabrication of sheathed uranium dioxide elements by packed-powder techniques. Both vibratory compaction and swaging are considered. (D.L.C.)

**12014** MATERIALS. p.38-42 of "Power Reactor Technology. Volume 6, No. 1."

A review is presented of recent studies of radiation effects on BeO. The DMIC literature review on Be metal and a recent paper on the improved ductility of Fe–40 wt% Al alloy are discussed briefly. The results of a British study on the effects of long on-site stress-relieving times on the properties of pressure-vessel steels and of an American study on stress relaxation of stainless steel under irradiation are summarized. (D.L.C.)

**12015** DESIGN PRACTICE: THE N. S. SAVANNAH. p.43-54 of "Power Reactor Technology. Volume 6, No. 1."

A summary is presented of some design details of the N.S. Savannah power plant as examples of design practice in pressurized-water reactors for marine application. (D.L.C.)

**12016** OPERATING EXPERIENCE: HEAVY-WATER LOSSES FROM POWER REACTORS. p.55-6 of "Power Reactor Technology. Volume 6, No. 1."

The heavy $D_2O$ losses that occurred in the Plutonium Recycle Test Reactor (PRTR) are discussed, and the possibility of reducing the losses is considered. Recommendations based on PRTR operating experience are summarized. (D.L.C.)

**12017** SODIUM-COOLED REACTORS. p.57-61 of "Power Reactor Technology. Volume 6, No. 1."

The operation of Sodium Reactor Experiment is described. Instability was observed which is ascribed to bowing of the fuel rod clusters, and the rods were made more rigid by means of helical wire wraps. The topics treated in the Symposium on Sodium Reactors Technology are described briefly. (D.L.C.)

**12018** ORGANIC-COOLED REACTORS. p.62-73 of "Power Reactor Technology. Volume 6, No. 1."

A review is presented on the status of organic-cooled reactor technology. Constructed and planned reactors of both the organic-moderated and heavy water-moderated types are discussed. Radiation effects and energy deposition in organic coolants are considered in some detail. (D.L.C.)

**12019** GAS-COOLED REACTORS. p.74-80 of "Power Reactor Technology. Volume 6, No. 1."

The status and design of the Dragon reactor are described. The fuel element, fission product handling, fuel handling, and problems in Dragon are discussed. The present status of gas-circulating machinery for gas-cooled reactors is outlined. (D.L.C.)

**12020** ADVANCED SHIP-PROPULSION STUDIES. p.81-4 of "Power Reactor Technology. Volume 6, No. 1."

Several advanced concepts for pressurized-water ship-propulsion reactors are described. The concepts involve the self-pressurization of the reactor and the superheating of the secondary steam by the primary coolant water. A heat balance diagram is given. (D.L.C.)

## Production Reactors

**12021** APPROACH TO THE DEVELOPMENT OF A FAST BREEDER REACTOR. W. Haefele and K. Wirtz (Kernforschungszentrum Carlsruhe, Ger.). Atomwirtschaft, 7: 557-9(Nov. 1962). (In German)

The necessity for breeder reactors in a long-term nuclear energy program has frequently been stressed. A fast breeder reactor can be built in two basically different ways. In the case of external breeding, the fissionable material is in a very small inner zone and the breeding material surrounds it in a so-called breeding blanket. With internal breeding the fissionable and breeding materials in a suitable mixture are in a common reactor core. The advantages and disadvantages of both types are compared. The development being done on a fast breeder reactor in the Federal Republic is indicated. (auth)

## Research Reactors

**12022** (BLG-147) CARACTERISTIQUES NEUTRONIQUES DES FAISCEAUX ISSUS DE BR2. (Characteristics of Neutron Beams from BR2). M. Neve de Mevergnies and E. Legrand (Brussels. Centre d'Etude de l'Energie Nucléaire). Oct. 1962. 18p.

Characteristics of the beams from the $T_7$ (tangential) and the $R_3$ (radial) channels were studied at a reactor power of about 10 w. Measurements were made of the absolute neutron intensity, the approximate neutron spectrum, the gamma dosage, and the optimum position of the source in the $T_7$ channel. The expected performances of the BR-2 at about 50 Mw were estimated using these results. (J.R.D.)

**12023** (IKF-1) THERMISCHE UND EPITHERMISCHE NEUTRONENFLÜSSE UND STRAHLINTENSITÄTEN AM FRF. (Thermal and Epithermal Neutron Flux and Radiation Intensity at the FRF). K. Stelzer (Johann-Wolfgang-Goethe-Universität, Frankfurt am Main. Institut für Kernphysik). Oct. 1961. 42p.

The distributions of thermal and epithermal neutron fluxes in the experimental arrangements of the Frankfurt Research Reactor (FRF) were measured by indium probes. Absolute values were determined with gold probes. The relative local distribution of neutron fluxes outside of the core tank depends only a little on the reactor power so that the neutron flux in the experimental arrangements can be stated absolutely in $N \cdot cm^{-2} \cdot sec^{-1}$ per watt of reactor power. For the outside of the concrete shielding in a collimated neutron beam, a relation derived for available neutron fluxes was confirmed by measurements at a beam channel. In addition to this relation, the suitability of the various beam channels for different groups of experiments was investigated. (tr-auth)

**12024** (IKF-3) ÜBERPRÜFUNG EINES EINFACHEN MODELLS FÜR EINEN WASSERKOCHER-REAKTOR. (Testing of A Simple Model for a Boiling-Water Reactor). U. Kaczmarek and K. Stelzer (Johann-Wolfgang-Goethe-Universität, Frankfurt am Main. Institut für Kernphysik). Oct. 1962. 38p.

A simple model for the dynamic behavior of the Frankfurt Research Reactor (FRF) was reproduced on an analog computer. The constants of the models were ascertained by experiments on the FRF. In order to check the model, transition curves of the output as a result of the slope function of the reactivity were calculated. They were compared with transition curves determined experimentally on the FRF up to reactivity changes of $0.31. The comparison showed that the model represented well the output maxima and the trend of the transition curves in the region considered. The best agreement between calculation and experiment was obtained with a temperature coefficient of $\alpha = -4.54 \times 10^{-2}$ dollar/°C and a stationary output coefficient for the radiolytically formed bubbles of $-2.96 \times 10^{-3}$ dollar/kw. The model may be used for investigation of control mechanisms and for the treatment of safety questions for reactivity changes of 0 to 0.45 dollar. (tr-auth)

**12025** (NP-12299) NORTHROP REACTOR. REVISION NO. 1 TO THE FINAL SAFEGUARDS REPORT. James M. Duncan, Ben Shimizu, and Richard A. Romine (Northrop Corp. Northrop Space Labs., Hawthorne, Calif.). Oct. 1962. 139p. (NSL-62-212)

Additions and changes related to the original application concerning construction and operation of the Northrop Reactor are given. Answers to 13 questions relative to the Final Safeguards Report are included. Answers are also included concerning 12 questions regarding receipt, possession, and storage of fuel elements. Other information is included concerning personnel changes and changes from Al-clad fuel elements to improved stainless steel-clad hydride elements. It is concluded that the improved Northrop Reactor does not present any undue hazard to the health and safety of the operating personnel or the public. (J.R.D.)

**12026** NUCLEAR REACTORS IN THE SERVICE OF MEDICINE. THE COOPERATION BETWEEN THE REACTOR PLANT AND THE INSTITUTE FOR MEDICINE IN THE NORDRHEIN-WESTFALEN/JULICH NUCLEAR RESEARCH INSTALLATION. O. W. Schroeder (Kernforschungsalage, Julich, Ger.). Atomkernenergie, 7: 373-4 (Oct. 1962).

A brief survey is given on the future cooperation between the reactor stations and the Institute for Medicine being established at the Nuclear Research Installation Nordrhein-Westfalen/Jülich according to the well-tested model of the Clinical Department in the Atomic Center of Brookhaven, USA. The capacities are mentioned and the desired requirements of medicine are enumerated by way of examples. A discussion of the advantages of a pulse reactor for medical research is given. (auth)

**12027** FUEL ELEMENTS OF URANIUM OXIDE–POLYETHYLENE DISPERSIONS. H. J. Hein. Atomwirtschaft, 7: 553-7(Nov. 1962). (In German)

The German Siemens training reactor SUR-100 has a core of $U_3O_8$ embedded in a dispersion in polyethylene as moderator. The design and construction of the fuel elements are described. The core consists of several circular plates 24-cm in diameter that are stacked to form a cylinder about 26 cm high. The proportion of $U_3O_8$ and polyethylene is so adjusted that the finished plates have a $U^{235}$ concentration of 60 $mg/cm^3$. This concentration de-

pends on the kind of polyethylene used and on the isotope analysis of the oxide and is reached approximately with a $U_3O_8$ proportion of 30% by weight. The density, mechanical testing, and control of the thermal stability of the fuel elements are discussed. (auth)

**12028** LONDON UNIVERSITY'S FIRST REACTOR, CONSORT II FOR SILWOOD PARK. Nucl. Eng., 8: 30-1 (Jan. 1963).

The Consort II Reactor for installation at the Imperial College of Science and Technology is described. The 100 kw research reactor is light water moderated and cooled, and fueled with 80% enriched U alloyed with Al in MTR-type Al-clad elements. A provisional program for utilization of the reactor is presented. (M.C.G.)

**12029** COMPARATIVE PERFORMANCE OF BLACK vs. GRAY CONTROL RODS IN THE ENGINEERING TEST REACTOR. E. E. Burdick and D. G. Proctor (Phillips Petroleum Co., Idaho Falls, Idaho). Nucl. Sci. Eng., 14: 384-9(Dec. 1962).

Flux changes caused by withdrawing black and gray control rods in the ETR are compared. The flux changes are shown to be the same for each type of rod at distances greater than three inches from the rod. Closer to the rod, the gray rod is successful in reducing the flux change. In terms of the flux change per unit reactivity effect, the differences between the black and the gray rod is not noticeable beyond 1.5 in. (auth)

**12030** NEUTRON DIFFRACTOMETER MEASUREMENT OF THE SLOW NEUTRON SPECTRUM FROM A MODIFIED SPLIT REACTOR CORE. G. A. Ferguson, Jr. and R. H. Vogt (Naval Research Lab., Washington, D. C.). Nucl. Sci. Eng., 14: 397-400(Dec. 1962).

Neutron diffraction techniques are used to measure the slow neutron spectrum of a beam from the NRL reactor with a modified split core. The effectiveness of the use of one or more split fuel elements of special design to optimize the thermal flux is determined. On the basis of the measurements, it is concluded that split elements may be used to reduce the background of high-energy neutrons without depleting the thermal flux in a beam from the core. (auth)

**12031** 12 YEARS EXPERIENCE OPERATING THE BROOKHAVEN GRAPHITE REACTOR. Dudley Thompson (Brookhaven National Lab., Upton, N. Y.). Nucleonics, 21: No. 2, 60(Feb. 1963).

Trends in the causes of unscheduled shutdowns were considered, and possible methods for reducing shutdowns were suggested. (C.E.S.)

**12032** INSTALLATION FOR STUDYING CONDENSED SUBSTANCE DYNAMICS BY MEANS OF INELASTIC COLD NEUTRON SCATTERING. M. G. Zemlyanov and N. A. Chernoplekov (Inst. of Nuclear Energy, Academy of Sciences, USSR). Pribory i Tekhn. Eksperim., No. 5, 40-7 (Sept.-Oct. 1962). (In Russian)

Dynamics of condensed substances was investigated using an inelastic cold neutron scattering assembly on the IRT-1000 reactor. Spectra are given for elastic and inelastic scattering on vanadium. (tr-auth)

# SPACE APPLICATIONS AND TECHNOLOGY

*Refer also to abstract 11262.*

**12033** (ASD-TDR-62-591) STUDY OF ADVANCED FLIGHT-VEHICLE POWER-UTILIZATION SYSTEMS. Final Report, March 21, 1961–June 30, 1962. (General Dynamics/Fort Worth. Div. of General Dynamics Corp., Fort Worth, Tex.). June 30, 1962. Contract AF33(616)-8179. 100p. (AD-278204; FZK-148)

An unconventional approach toward utilization of vehicle power is presented. Brief mission profiles are given for six manned and unmanned air and space craft to give the schedule of operation of systems which utilize power. Greater detail is presented on the power utilization of two of these, the unmanned reconnaissance satellite and the manned lunar-landing and return vehicle. A general discussion is presented on power sources intrinsic and extrinsic to vehicles, and a forecast is shown for chemical, solar, and nuclear sources. The application of the morphological method to the development of new concepts is discussed and examples given of several "morphological boxes". Some of the concepts that developed during the course of the study are also given. In addition, general reviews of Electromagnetic Wave Amplification by Stimulated Emission of Radiation, radio space communications, and electrical propulsion are given. It was concluded that a modified morphological approach offers a better framework for conceiving advanced concepts. Recommendations are made for further study and development of the method and new concepts. (auth)

**12034** (NP-12353) THE NUCLEAR EFFECT OF USING LITHIUM HYDRIDE AS THE PROPELLANT IN A NUCLEAR ROCKET REACTOR (thesis). Robert Owen Bartlett (Air Force Inst. of Tech., Wright-Patterson AFB, Ohio). May 1962. 128p. (GNE/Phys/62-3)

The nuclear effect of using LiH, containing Li of various isotopic percentages of $Li^6$ and $Li^7$, as a nuclear rocket propellant was investigated by applying a modified two-group neutron diffusion theory for a side reflected cylindrical reactor to a model reactor composed of a core containing a homogeneous mixture of $U^{235}$, $U^{238}$, $C^{12}$, and LiH; and an infinite Be reflector. Numerous reactor problems were solved for the critical mass of the reactor containing masses of LiH from 0 to 100 Kg with $Li^7$ enrichments from 90 to 100%, for nuclear operating temperatures of 5330, 4280, and 3420°F. These problems were solved with a nuclear reactor digital computer code, called "ROCKET," which was written specifically for this investigation. The results of this investigation indicate that the nuclear effect of using LiH is that of a poison. This poisoning effect is directly related to the amount of $Li^6$ present in the Li. For all three operating temperatures considered, the critical mass requirement of the reactor increases linearly with the addition of LiH such that the slope of this increase is linearly related to the isotopic percentage of the $Li^6$ present in the Li. Isotopic percentages of $Li^6$ greater than 1% cause an excessive penalty to be paid in terms of fuel loading in order to achieve criticality. The critical mass requirement of the reactor with no LiH present, operating at 5330°F, increases by factors of 1.04, 2.2, 3.33, 7.75, 12.2, and 17.7 with the addition of 100 Kg of LiH containing $Li^6$ isotopic percentages of 0%, 0.5%, 1%, 3%, 5%, 7.4%, and 10% respectively. Similar results were obtained for operating temperatures of 4280 and 3420°F, however, a slight increase in the poisoning effect with a decrease in temperature was noted. The feasibility of using LiH as a nuclear rocket propellant appears remote without the removal of at least all but 1% of the $Li^6$ from the Li. When the handling and storage problems associated with using LiH are coupled with the imposed penalty in terms of fuel loading, the use of this material as a nuclear rocket propellant appears unfeasible. (auth)

**12035** (NP-12492) A SHORT REVIEW OF SPACE POWER SYSTEM TECHNOLOGY. (Republic Aviation Corp. Missile Systems Div., Mineola, N. Y.). May 18, 1962. 42p.

A brief review is presented of various power systems currently available for space vehicles. The systems discussed are solar cells, primary batteries, secondary batteries, fuel cells, solar thermionic systems, nuclear power systems, chemical systems, and microwave power transmission. The pertinent characteristics of the available power systems for space application are summarized and compared with each other for specific power levels and missions. (D.L.C.)

**12036** (SY-5396-R3) SPUR POWER SYSTEM QUARTERLY PROGRESS REPORT FOR PERIOD ENDING DECEMBER 31, 1962. F. B. Wallace (AiResearch Mfg. Div., Garrett Corp., Phoenix, Ariz.). Jan. 15, 1963. Contract AF33(657)-8954. 192p.

Activities are reported on testing of Mo–Ti and Nb–Zr alloys, fabrication of refractory materials, testing of liquid-K bearings, design of turbine test facility, development of turbine materials, development of SPUR generator, testing of boiling-K heat transfer, development of stainless steel heat transfer components, design of heat transfer loop, and development of a reactor loop. (J.R.D.)

**12037** CLOSED LOOP DYNAMICS OF NUCLEAR ROCKET ENGINES WITH BLEED TURBINE DRIVE. Harold P. Smith, Jr. (Univ. of California, Berkeley). Nucl. Sci. Eng., 14: 371-9(Dec. 1962).

The dynamics of nuclear rocket engines is studied, with attention to integral temperature error feedback control of reactivity and proportional pressure error feedback control of propellant flow with first order lags placed between the desired controller positions and the actual positions. The resulting series of ordinary, nonlinear differential equations are approximated by a linear model in order to analyze the low-frequency dynamics. It is shown that the low and high frequencies may be decoupled and that the proposed method of control is stable for small variations away from any point of steady-state operation. Algebraic equations, in terms of design parameters, are derived for control settings that yield optimum response characteristics. It is further shown that the asymptotic response is improved by reduction of the mechanical inertia of the turbopump but is independent of the thermal inertia of the core. The analysis is corroborated by analog simulation of the nonlinear model for the case of low-power–high-power transition, using only feedback control for flow and reactivity variation. (auth)

**12038** SINGLE-STAGE SPACESHIPS SHOULD BE OUR GOAL. Maxwell W. Hunter, Jr. (National Aeronautics and Space Council, Washington, D. C.). Nucleonics, 21: No. 2, 42-5(Feb. 1963).

The ultimate vehicle for manned space travel within the solar system was considered to be the high-performance single-stage spaceship—a vehicle that could travel from earth to points in space and back time after time. If the performance of single-stage rockets can be made high enough, one can begin to think of reusing equipment exactly as in transport airplane practice. The prospects for a practical gaseous fission rocket have brightened with the recent invention of a new family of systems that operates on a basically different principle. The propellant is heated by radiation from the fission plasma, rather than by direct intermixing. Several such systems were suggested. Safety factors were considered to make operation of a spaceship propelled by a gaseous-fission engine safe. (C.E.S.)

**12039** POWER-PRODUCING SHIELD FOR SPACE REACTORS. Bernard Raab (Republic Aviation Corp., Mineola, N. Y.). Nucleonics, 21: No. 2, 46-7(Feb. 1963).

The active-shield or basic converter unit consisted of an assembly of high-Z and low-Z materials, divided about equally in weight and separated by a vacuum or dielectric. The reactor radiations interact with the active-shield to create anode-cathode voltage. (C.E.S.)

# WASTE DISPOSAL AND PROCESSING

*Refer also to abstracts 10822 and 10844.*

**12040** (HW-74712) FISSION PRODUCT AND WASTE PACKAGING—EFFECT OF GAMMA LEAKAGE ON THERMAL CALCULATIONS. L. H. Steves and W. V. DeMier (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Aug. 24, 1962. Contract AT(45-1)-1350. 8p.

Estimates of thermal conditions in containers of $Cs^{137}$ loaded zeolites can be considerably in error if gamma leakage is ignored. For example, for a centerline temperature of 1300°F, and a loading of 2 milliequivalents Cs per gram, correction for gamma leakage permits increasing the bed diameter from 10.3 inches to 12.25 inches; a 40% increase in fission product capacity for a given container length. (auth)

**12041** (HW-SA-2192) THE EFFECTIVENESS OF HIGH COAGULANT FEED IN REDUCING HANFORD REACTOR EFFLUENT RADIOISOTOPE CONCENTRATIONS. W. B. Silker (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). July 14, 1961. Contract AT(45-1)-1350. 28p.

Activities are reported in an investigation aimed at developing a method by which the radioisotopes discharged to the Columbia River in the Hanford Production Reactor cooling water can be reduced. Aspects of removal of the parents of $P^{31}$, $S^{32}$, $As^{76}$, $Zn^{64}$, and $U^{235+238}$ are examined. Results of reductions using aluminum nitrate coagulant are included. (J.R.D.)

**12042** (MSAR-61-34) DECONTAMINATION OF RADIOACTIVE COMPONENTS. Final Technical Report. S. J. Rodgers and W. A. Everson (MSA Research Corp., Callery, Penna.). Mar. 15, 1961. For Westinghouse Electric Corp., Pittsburgh. Contract NObs-78844, Subcontract 73-44-953. 77p.

A study was conducted to provide information on decontamination of nuclear power plant components for use in a handbook. Methods of decontaminating waste solutions were also investigated. Flushout studies on dead-end legs indicate the desirability of high flow rates in such operations. Excellent results were obtained with basic $KMnO_4$-citrate solutions used in conjunction with ultrasonics. (J.R.D.)

**12043** (NP-12482) DECONTAMINATION OF RADIOACTIVE WATER. (Organization for Economic Co-Operation and Development, Paris). [1961]. 24p.

Two hundred and ninety-three references on decontamination of radioactive water are presented. The references are arranged alphabetically by author. (M.C.G.)

**12044** (TID-7646) REPORT OF THE THIRD WORKING MEETING ON CALCINATION AND/OR FIXATION OF HIGH LEVEL WASTES IN STABLE, SOLID MEDIA AT WASHINGTON, D. C., FEBRUARY 1-2, 1962. Wililam H. Regan, comp. and ed. (Division of Reactor Development, AEC). 104p.

Papers presented at the Third AEC Meeting on Calcination and/or Fixation of High-Level Wastes in Stable, Solid Media are given. Separate abstracts were prepared for each of the 8 papers. (M.C.G.)

**12045** (TID-7646(p.3-19)) FLUIDIZED-BED CALCINATION. J. I. Stevens.

Fourteen runs were carried out in either the 2-ft square fluidized-bed calciner or the 12-in. diameter calciner with most of these runs having a duration of about 10 days. Construction of the Demonstrational Waste Calcination Facility (DWCF) was completed and several runs were made. The bed temperatures investigated ranged from 250 to 550°C. The effects of aluminum concentration in the feed were studied along with the effects of intraparticle porosity and absolute density. Nozzle designs and materials were investigated. Performances of the various calciners are discussed. (M.C.G.)

**12046** (TID-7646(p.20-36)) CALCINATION OF RADIOACTIVE WASTES IN MOLTEN SULFUR. M. W. Davis, Jr.

A method for converting radioactive wastes to a relatively insoluble form is described. The aqueous acidic wastes are heated in molten sulfur so that the water and volatile acids are driven off and the chemical compounds are decomposed and/or chemically reduced. The sulfur acts as a liquid heat-transfer medium and also tends to minimize dusting. It provides an insoluble matrix that reduces markedly the leachability of the fission products. Studies to determine the best conditions for converting the bulk material to a relatively insoluble form were carried out with non-radioactive feed solutions that contained trace levels of Cs, Sr, and Ru. The trace elements were used to determine the leachability of the product by water over extended periods of time and to determine how much $RuO_4$ and particulate matter the calcination produces in the off-gas. (M.C.G.)

**12047** (TID-7646(p.37-42)) BALL KILN CALCINATION. L. P. Hatch.

Work on ball kiln calcination involved studies of the rotary seal and the solution feeder. The calciner consists of an Inconel tube 8 in. in diameter and 7 ft long, about $\frac{1}{3}$ full of $\frac{3}{4}$-in. diameter stainless steel balls, and surrounded by an electric furnace. The rotating kiln is joined to a stationary product receiver by means of a rotary seal at the discharge end. There is a rotary joint in the feed line to the kiln. It is supported on trunions and driven by means of a chain-sprocket drive connected to a variable speed electric motor. The rotary seal utilizes the principle of supplying steam under pressure between two sealing faces in such a manner that leakage of the steam into the system prevents escape of radioactive dust. (M.C.G.)

**12048** (TID-7646(p.43-51)) CONTINUOUS PHOSPHATE GLASS PROCESS. E. J. Tuthill.

A continuous process for converting high-level radioactive wastes to stable phosphate glasses is being developed. As applied to Purex wastes, concentrated $H_3PO_4$ was met with concentrated Purex waste at a ratio of 1 to 5. This solution was evaporated at 130°C, heated at 1100°C, and cooled. After cooling the resultant phosphate glass is suitable for permanent storage or disposal. Two modes of operation are being studied; in the first glass is continuously formed in a platinum-clad crucible and continuously drawn off into a removable burial container, in the other glass is formed in an $Al_2O_3$ crucible and buried in the same container. For high-aluminum-content wastes it was found to be necessary to add iron to obtain a good glass. (M.C.G.)

**12049** (TID-7646(p.52-68)) POT CALCINATION. R. E. Blanco.

The pot calcination process is described. Wastes are fed into an evaporator where nitric acid is taken off overhead. The concentrate from the evaporator, containing all the activity, is fed to a stainless steel pot where it is calcined at 900°C. Chemical and engineering development work and the design program are described. (M.C.G.)

**12050** (TID-7646(p.69-82)) COLD ENGINEERING DEVELOPMENT OF THE POT CALCINATION PROCESS. J. O. Blomeke.

Engineering aspects of the pot calcination process are discussed. Process flowsheets are presented. Results from 20 engineering scale pot calcination tests are summarized. (M.C.G.)

**12051** (TID-7646(p.83-93)) RADIANT SPRAY CALCINATION. R. T. Alleman.

A schematic diagram of a spray calcination plant is presented. Feed is sprayed by means of a two-fluid nozzle into the top of a heated column. The spray dries almost instantaneously as it is calcined as it falls down the column. Calcined powder is collected in a pot-off-gases pass through filters into a down-draft condenser, scrubbers, silica-gel absorbers, more filters, and finally into the vacuum jet of the building duct work. Results obtained in spray calcination of various types of wastes are discussed. (M.C.G.)

**12052** (TID-7646(p.94-101)) THE CERAMIC SPONGE PROCESS. C. W. Christenson.

The ceramic sponge process involves the use of a highly porous clay body or ceramic sponge that was fired to about 1100°C. This sponge is soaked in liquid wastes, dried, and resoaked. The cycle is repeated until the sponge is saturated with solids. The clay body is then fired at 1300°C to fix the radionuclides permanently. A 25-gallon per day pilot plant for this process was constructed and shake down runs were carried out. (M.C.G.)

**12053** TREATMENT OF RADIOACTIVE WASTES. J.-C. Marillier. Energie Nucl., 4: 320-31(Sept.-Oct. 1962). (In French)

The most important sources of radioactive wastes—nuclear central laboratories, power reactors, plants for fuel element fabrication, and plants for the processing of irradiated fuels—and the principal treatments used for their decontamination are reviewed. The evaporation procedure, the most efficient, is examined more closely from the viewpoint of actual installations with a schematic representation of the principal American and European evaporators. The characteristics that such an installation should possess (operational safety, minimum maintenance, vapor economy, high decontamination factor, and maximum concentration) are described. (tr-auth)

**12054** RADIOACTIVE WASTES—ORIGIN, HAZARDS AND TREATMENT. Per-Olof Kinell (AB Atomenergi, Studsvik, Tystberga, Sweden). Svensk Kem. Tidskr., 74: 575-96(1962). (In Swedish)

When energy is produced by nuclear fission, radioactive wastes also are obtained. These are formed in all steps from the mining of uranium ore to the operation of reactors. They also arise from the application of radioactive nuclides in industry and research. Due to the action of the radiation on the different organs in the human body uncontrolled handling of the waste has to be avoided. One of the most important safety precautions is to collect the various types of wastes and treat them by chemical processes to concentrate the radioactivity into a solid of small volume from which it can leak only very slowly. These concentrates have to be stored under controlled conditions for many generations. (auth)

# CORPORATE AUTHOR INDEX

This index contains entries for all report literature and, in addition, for certain published literature items for which it is felt that a corporate approach is especially desirable, e.g., symposia, conference proceedings, and meetings.

Each entry under a corporate author is a shortened version of the title of the publication, followed by the *NSA* volume and abstract number. Report numbers are given in parentheses.

The phrase "Progress report" is abbreviated as "Prog. rpt." This change permits a more rapid and complete alphabetical arrangement of the titles without changing the location of the progress report titles in relation to the other titles.

## A


**AEROJET-GENERAL CORP., AZUSA, CALIF.**
Mercury corrosion loop testing, 17: 11131 (AGC-0584-04-5)
Prog. rpt. on stress-corrosion cracking of high-strength, 17: 11099 (NP-12475)

**AEROJET-GENERAL NUCLEONICS, SAN RAMON, CALIF.**
HECTIC-II, IBM-7090 FORTRAN program for heat transfer analysis, 17: 10795 (IDO-28595)
Spectral analysis of GCRE and ML-1 reactor, 17: 11978 (AGN-TM-399)

**AERONAUTICAL SYSTEMS DIV. APPLICATIONS LAB., WRIGHT-PATTERSON AFB, OHIO.**
Literature survey on selected boride compounds, 17: 10579 (ASD-TDR-62-873)

**AERONAUTICAL SYSTEMS DIV. METALS AND CERAMICS LAB., WRIGHT-PATTERSON AFB, OHIO.**
Computer program for the Matano analysis of binary diffusion data, 17: 11301 (ASD-TDR-62-858)

**AEROPROJECTS, INC., WEST CHESTER, PENNA.**
Prog. rpt. on cleaning organic moderated fuel elements, 17: 11954 (NYO-10284)
Ultrasonic filling of cladding with ceramic powders, 17: 11162 (CEND-153(Vol.II)(p.163-94))

**AIR FORCE CAMBRIDGE RESEARCH LABS. GEOPHYSICS RESEARCH DIRECTORATE, BEDFORD, MASS.**
Transmission of thermal radiation from nuclear detonations, 17: 11298 (AFCRL-62-456)

**AIR FORCE INST. OF TECH., WRIGHT-PATTERSON AFB, OHIO.**
Cadmium sulfide as nuclear radiation detector, 17: 11006 (NP-12376)
Displacement of Se atom in single-crystal ZnSe, 17: 11320 (NP-12360)
Nuclear effect of LiH as propellant in nuclear rocket reactor, 17: 12034 (NP-12353)
Radiation effects on solar cells, 17: 11263 (NP-12361)
Sampling of airborne radioactive particles, 17: 10856 (NP-12351)
Solving one-group-diffusion-equation with variable coefficients, 17: 11590 (NP-12368)
Sputtering by incident positive ions, 17: 11318 (NP-12357)

**AIR FORCE TECHNICAL APPLICATIONS CENTER, WASHINGTON, D. C.**
Seismic measurements for Mad, 17: 10245 (NP-12524)

**AIRESEARCH MFG. DIV., GARRETT CORP., PHOENIX, ARIZ.**
Prog. rpt. on SPUR power progmm, 12/13/62, 17: 12036 (SY-5396-R3)

**AKADEMIYA NAUK S.S.S.R.**
Automatic closed orbit control, 17: 11811 (NP-tr-932)
Influence of spin on position of Regge poles, 17: 11485 (NP-12478)
Removing ghost on vacuum Regge pole trajectory, 17: 11486 (NP-12479)

**AKTIEBOLAGET ATOMENERGI, STOCKHOLM.**
Backscattering of $\gamma$ radiation from spherical concrete walls, 17: 11896 (AE-93)
Backscattering of $\gamma$ radiation from plane concrete walls, 17: 11895 (AE-92)
Bibliography on radiation effects on U-based fuel materials, 17: 11269 (VDIT-16(2.4))
Burnout conditions for flow of boiling $H_2O$ in vertical annuli, 17: 10789 (AE-100)
Cross sections for neutron inelastic scattering and (n,2n) processes, 17: 11587 (AE-88)
Isomorphic substitutions of Ca by Sr in Ca hydroxyapatite, 17: 10576 (AE-96)
Multiple reflection of $\gamma$ radiation in spherical concrete wall room, 17: 11897 (AE-94)
Neutron streaming in $D_2O$ pipes, 17: 11588 (AE-98)
Paramagnetism of dissolved Mn in $\alpha$ and $\beta$ brasses, 17: 11297 (AE-95)

**ALLIS-CHALMERS MFG. CO., MILWAUKEE.**
Rod burnout heat flux tests for Pathfinder, 17: 11977 (ACNP-62028)
Vibratory and swage compaction of fuel rods, 17: 11151 (CEND-153(Vol.I)(p.149-62))

**ALLIS-CHALMERS MFG. CO. ATOMIC ENERGY DIV., WASHINGTON, D. C.**
Control rod worth for EGCR, 17: 11958 (TID-11601)
Extrusion of $UO_2$ and $ThO_2$–$UO_2$ fuels, 17: 11161 (CEND-153(Vol.II)(p.135-54))
Fuel assembly and heat transfer for EGCR. I., 17: 11989 (TID-11604)

**AMERICAN NUCLEAR SOCIETY, OAK RIDGE, TENN.**
Conference on nuclear education, Gatlinburg, 8/62, 17: 10247 (TID-7638)

**AMES LAB., AMES, IOWA.**
Cation exchange in acetone–$H_2O$–HCl, 17: 10733 (IS-466)
Electric resistivity of rare-earth alloys, 17: 11190 (IS-477)
Electron requirements of bonds in metal borides, 17: 11306 (IS-473)
Formation constants of rare earth complex species, 17: 10501 (IS-458)
Growth of single crystals of Pb, Cd, and Bi, 17: 10502 (IS-542)
Hydrolysis of rare-earth carbides, 17: 10591 (IS-499)
Nuclear quadrupole interactions and resonance frequencies. I., 17: 10592 (IS-520)
Preparation and properties of $MoBr_4$, 17: 10590 (IS-487)
Progress in sintering, 17: 11090 (IS-460)
Reaction mechanisms for (γ,n) activated $C^{11}$ reactions in liquid cyclohexane, 17: 10675 (IS-425)
Reactions of Nb(V) halides with pyridine, 17: 10500 (IS-385)
Separation of divalent metal ions from rare earths, 17: 10734 (IS-508)
Solutions of Ga(I) salts in aqueous base, 17: 10589 (IS-481)
Thermal efficiency of coated annular fins, 17: 10796 (IS-571)

**ARCOS, S. A., BRUSSELS.**
Prog. rpt. on stresses in welding, 4–6/62, 17: 11172 (EURAEC-391)
Prog. rpt. on stresses in welding, 7–9/62, 17: 11173 (EURAEC-446)

**ARGENTINA. COMISIÓN NACIONAL DE ENERGÍA ATÓMICA, BUENOS AIRES.**
Calibration of radioisotopes by CNEA, 17: 10677 (NP-12235)

Electrometric amplifier, 17: 10899 (NP-12229)
Production of radioisotopes with synchrocyclotron, 17: 10676 (NP-12231)
Production of thin plates of $UO_2$, 17: 11167 (NP-12228)

**ARGONNE NATIONAL LAB., ILL.**
Alkaline thermionic converters, 17: 11837 (TID-16215)
Alloy chemistry of transition elements, 17: 11180 (ANL-FGF-337)
Alpha half lives of Po-216, At-217, and Rn-218, 17: 11632 (TID-16202)
Analysis of $\gamma$ spectra, 17: 11444
Capture-to-fission ratio determination, 17: 11963 (TID-17738)
Computer program for analysis of complex $\beta$ spectra, 17: 11443
Computer study of noise measurement errors, 17: 10916 (TID-17788)
Construction of muscle-equivalent environmental radiation meter, 17: 11011 (TID-17824)
Contamination and decontamination studies related to BWR, 17: 11959 (TID-15779)
Control rod calibrations for Juggernaut, 17: 11964 (TID-17815)
Correlation of color and non-stoichiometry, 17: 11327 (TID-15759)
Deflection methods for 50-Mev proton beam, 17: 11807 (TID-17829)
Determination of Ge in mineral specimens, 17: 10574
Diffusion of Fe and Cr in beta U, 17: 11079 (ANL-FGF-334)
Disassembly of high level Pu glove box systems, 17: 10866 (TID-16203)
Effect of dissociation on negative H ions in cyclotrons, 17: 11799 (TID-17617)
Effects of $\gamma$ radiation on mouse testis, 17: 10361 (TID-15852)
Energy-dependent multiple scattering of neutrons, 17: 11595 (TID-15571)
Experiments with superconducting wire and solenoids, 17: 11335 (TID-17827)
External proton beam of ZGS, 17: 11800 (TID-17642)
Extraction of U(VI) by phosphates and phosphonates, 17: 10745 (TID-15773)
Fast ejection of proton beams from synchrotron, 17: 11801 (TID-17652)
Film copying technique for improving radiographic contrast, 17: 10891 (ANL-FGF-339)
Fluoride volatility processing of enriched fuels, 17: 10744 (TID-13765)
Galvanomagnetic properties of graphites, 17: 11103 (TID-16243)
Gamma-induced expansion of LiF, 17: 11266 (TID-15896)
Heat transfer in Couette flow of radiating fluid with viscous dissipation, 17: 10802 (TID-17664)
Helium-purification for inert-atmosphere boxes, 17: 10772 (ANL-6652)
High-voltage dividers for image intensifier tubes, 17: 10907 (TID-15860)
Interpretations of high-energy cross sections, 17: 11493 (TID-16216)
Investigation of fast reactor systems, 17: 11461 (TID-17817)
Lifetimes of radioactive sources, 17: 11628 (TID-15849)
Local distribution and retention of Ra in man, 17: 10309 (TID-17644)
Magnetic measurements of bending magnet BM-102, 17: 11804 (TID-17693)
Meeting on bio-assay and analytical chemistry, 10/61, 17: 10522 (ANL-6637)
Mirror-symmetry in beam transport systems, 17: 11802 (TID-17661)
Neutron and x-ray diffraction studies on non-stoichiometric metal hydrides, 17: 10578 (ANL-FGF-332)
Neutron radiography, 17: 10814 (ANL-FGF-335)
One-electron redox reactions involving destruction of $MO_2^+$ structure, 17: 10596 (TID-15793)
Paramagnetic resonance of photolyzed solid $H_2O_2$, 17: 10679 (TID-15898)
Positron elastic scattering by atomic H, 17: 11328 (TID-15769)
Prog. rpt. on physics, 9–10/62, 17: 11299 (ANL-6612)
Prog. rpt. on reactor development, 11/62, 17: 11935 (ANL-6658)
Prog. rpt. on reactor development, 12/62, 17: 11936 (ANL-6672)
Protons from 50 Mev to 12.5 Bev, 17: 11494 (TID-17627)
Pulsed-molecular-beam mass spectrometer, 17: 10910 (TID-16209)
Random paths on plane nets with internal traps, 17: 11907 (TID-15885)
Rapid beam ejector at Cosmotron, 17: 11785 (BNL-6678)
Removal of hydrolyzable radioelements, 17: 10523 (ANL-6637(p.5-8))
Scintillator-polaroid film camera for neutron image detection, 17: 10999 (ANL-FGF-340)
Separation of actinides with nitric acid–methanol and EDTA, 17: 10771
Separation of Y-91 and Pm-147, 17: 10746 (TID-15792)
Solid state particle detectors, 17: 11009 (TID-16206)
Solution of transition elements in liquid Al, 17: 10577 (ANL-FGF-292)
Structural aspects of organophosphorus extractants, 17: 10748 (TID-17726)
Swelling of U, 17: 11265 (TID-15774)
System to obtain higher space resolution in nuclear emulsions, 17: 11333 (TID-17640)
System UC–PuC, 17: 11181 (ANL-FGF-345)
Theory of a coaxial shunt, 17: 11334 (TID-17677)
Thermodynamic properties of $ZrH_2$, $ZrD_2$, $YH_2$, and $YD_2$, 17: 10597 (TID-15795)
Thymic lymphoma incidence and longevity of female mice irradiated with neutrons or $\gamma$ rays, 17: 10360 (TID-15850)
Tunnel diode circuit analysis, 17: 10890 (ANL-6634)
Unseparated antiproton beam for counter experiments, 17: 11803 (TID-17691)
Uranium dioxide–NaK slurry as reactor fuel, 17: 11077 (ANL-6644)
Vacuum brazing of superheater fuel plates, 17: 11078 (ANL-FGF-329)
Vapor-liquid equilibrium in $BrF_3$–$UF_4$ system, 17: 10595 (TID-15770)
Vaporization and thermodynamic properties of US and UOS, 17: 10598 (TID-15796)

**ARKANSAS. UNIV., LITTLE ROCK.**
Prog. rpt. on electron sources and mass spectrometers, 7/1–12/31/61, 17: 10898 (N62-10115)

**ARMY SIGNAL RESEARCH AND DEVELOPMENT LAB., FORT MONMOUTH, N. J.**
Capture of electrons into stable betatron orbits, 17: 11810 (USASRDL-TR-2257)

**ATHENS. UNIV.**
Prog. rpt. on radiation effects on lipid metabolism, 5–12/62, 17: 10365 (TID-17692)

**ATLANTIC RESEARCH CORP., ALEXANDRIA, VA.**
Prog. rpt. on boiling heat transfer, 9/60–2/62, 17: 10801 (NYO-10345)
Pyrolytic graphite in rocket motors, 17: 11076 (AD-278371)

**ATOMIC ENERGY OF CANADA LTD., CHALK RIVER, ONT.**
Close packed lattices in $H_2O$ and $D_2O$—spectrum, 17: 11940 (CRRP-895)
Cold swaging $UO_2$ in Zircaloy, 17: 11148 (CEND-153(Vol.I)(p.89-124))
Irradiation of hydraulic rabbit specimens, 17: 11256 (CRFD-1119)

**ATOMIC ENERGY OF CANADA LTD. CHALK RIVER PROJECT, CHALK RIVER, ONT.**
Lattice parameters for NPD and CANDU fuel elements in $D_2O$, 17: 11939 (CRL-75)

**ATOMICS INTERNATIONAL. DIV. OF NORTH AMERICAN AVIATION, INC., CANOGA PARK, CALIF.**
Critical heat flux of polyphenyl coolants, 17: 10800 (NAA-SR-7954)
Performance of Cs thermionic diodes, 17: 11315 (NAA-SR-7661)
Reprocessing studies on irradiated UC reactor fuel, 17: 10736 (NAA-SR-7511)
Seebeck coefficient apparatus, 17: 11316 (NAA-SR-Memo-6741)
SNAP II power conversion system CRU design, 17: 11986 (NAA-SR-6307)
Thermoelectric converter for SNAP, 17: 11314 (NAA-SR-7288)
Void and pressure by fission track nucleation during power bursts, 17: 11952 (NAA-SR-7086)

**AUSTRALIA. ATOMIC ENERGY COMMISSION RESEARCH ESTABLISHMENT, LUCAS HEIGHTS, NEW SOUTH WALES.**
Aqueous coordination chemistry of Be, 17: 10498 (AAEC/TM-161)
Neutron temperature measurement using Lu, 17: 11586 (AAEC-TM-164)
Two-group, three-region, fully reflected cylindrical reactor program for IBM 1620, 17: 11933 (AAEC/E-101)

## B

**BABCOCK AND WILCOX CO., LYNCHBURG, VA.**
Analysis of $H_2O$-moderated $UO_2$ and $ThO_2$ lattices, 17: 11938 (BAW-1257)

**BALLISTIC RESEARCH LABS., ABERDEEN PROVING GROUND, MD.**
Effects of $\alpha$ particles on polyethylene, 17: 10674 (BRL-1177)

**BATTELLE INSTITUT E. V., FRANKFURT AM MAIN.**
Measuring device in field of plasma electronics, 17: 11827 (AD-277601)

**BATTELLE MEMORIAL INST., COLUMBUS, OHIO.**
High-temperature irradiation test of $UO_2$ fuels, 17: 11254 (BMI-1608)
Reactor materials, Vol. 5, No. 3, 1962, 17: 11123
Reactor materials, Vol. 5, No. 4, Nov. 1962, 17: 11124
Semiconducting properties of rare earths, 17: 11296 (AD-278352)

Thermal conductivity of $UO_2$, 17: 11258 (HW-69945)
**BATTELLE MEMORIAL INST. DEFENSE METALS INFORMATION CENTER, COLUMBUS, OHIO.**
Electron microscopic fractography, 17: 11083 (DMIC-Memo-161)
Joining of Ni-base alloys, 17: 11163 (DMIC-181)
Selected accessions, 12/62, 17: 11100 (NP-12493)
**BATTELLE MEMORIAL INST. INTERNATIONAL DIV., GENEVA.**
Prog. rpt. on radiation effects on pressure vessel steels, 7–9/62, 17: 11188 (EURAEC-485)
**BEERS (ROLAND F.), INC., ALEXANDRIA, VA.**
Prog. rpt. on seismic data for Project Vela, 1/30–6/30/62, 17: 10238 (AD-278378)
**BOEING CO., SEATTLE.**
Analysis of fracture surfaces by electron microscopy, 17: 11185 (D1-82-0169)
Magnetogasdynamic source, 17: 11830 (D1-82-0166)
**BRANDEIS UNIV., WALTHAM, MASS.**
Prog. rpt. on radiation-induced reactions, 11/61–11/62, 17: 10680 (TID-17584)
**BRAZIL. UNIVERSIDADE, RIO DE JANEIRO.**
Production and spin of K* resonance, 17: 11487 (NP-12488)
**BROOKHAVEN NATIONAL LAB., UPTON, N. Y.**
Acceleration of deuterons or $\alpha$ particles in AGS, 17: 11784 (BNL-6673)
Beam current measurements in AGS, 17: 11782 (BNL-6645)
Biological effects of heavy cosmic particles, 17: 10353 (BNL-6098)
Boiling K heat transfer project loop design, 17: 10791 (BNL-6142)
Bone marrow cell transfusions, 17: 10292 (BNL-6106)
Bubble chamber track-centering device, 17: 11000 (BNL-6094)
Cell population studies on intestine of irradiated rats, 17: 10355 (BNL-6113)
Computer program to optimize magnets in beam transport system, 17: 11781 (BNL-6189)
Conference on high energy accelerator, USSR, 1961, 17: 11761 (BNL-767)
Cosmic ray produced Ar-37 and Ar-39 in meteorites, 17: 11448 (BNL-6545)
Cross sections of 14.5-Mev neutron reactions in Ca-47 formation, 17: 11614 (BNL-6044)
Deflecting mode in circular iris-loaded waveguide of r-f particle separator, 17: 11783 (BNL-6670)
Digital computer in development of positron scanning procedure, 17: 10357 (BNL-6572)
Distribution of U and Ce between liquid Bi–Mg and NaCl–KCl–$MgCl_2$, 17: 10581 (BNL-639)
Effects of radiations on early responses in mammal, 17: 10358 (BNL-6575)
Graphite problems in air-cooled reactors, 17: 11184 (BNL-758)
Kinetics of Ca-47 and Sr-85 in man, 17: 10293 (BNL-6108)
Late neurological effect following acute irradiation, 17: 10356 (BNL-6546)
Lead x rays that accompany Po-210 decay, 17: 11616 (BNL-6166)
Leukemogenic effect of whole-body $\gamma$ irradiation, 17: 10354 (BNL-6105)
Low frequency amplifier IH-130-1, 17: 10892 (BNL-6437)
Meteorological knowledge as factor in air pollution control, 17: 10843 (BNL-6538)
Milking systems for radioisotope separation, 17: 11050 (BNL-6697)
Neutron cross section newsletter, No. 7, 10/62, 17: 11613 (BNL-768)
Observation of $Li^6(n,\alpha)H^3$ reaction, 17: 11615 (BNL-6082)
Penetration effects in magnetic-dipole L-shell internal conversion, 17: 11618 (BNL-6647)
Polynomials encountered in distribution function of spacings, 17: 11063 (BNL-757)
Radiation damage in graphite. I., 17: 11255 (BNL-6083)
Radiation-induced effects in MgO catalysts, 17: 10672 (BNL-6097)
Rapid beam ejector at Cosmotron, 17: 11785 (BNL-6678)
Second-order effects of nuclear magnetic fields, 17: 11617 (BNL-6205)
Secondary $\alpha$-deuterium isotope effect in decomposition of $\alpha$-phenylethylazo-2-propane, 17: 10665 (BNL-6174)
Solvent extraction of Th by TTA, 17: 10727 (BNL-6099)
Synergistic effect in solvent extraction, 17: 10729 (BNL-6188)
Theory of process $p + p \rightarrow d + \omega^+$, 17: 11465 (BNL-6646)
Thermal annealing of recoil Br-82, 17: 10673 (BNL-6535)
Transport of fission products through soil, 17: 10820 (BNL-6554)
Uranium recovery from unirradiated fuel elements, 17: 10728 (BNL-6148)
Vapor-liquid equilibrium in $BrF_3$–$UF_6$ system, 17: 10595 (TID-15770)
Versatile bubble-chamber track measuring stage, 17: 11001 (BNL-6095)
Volatility reprocessing of reactor fuels, 17: 10730 (BNL-6195)
**BROWN BOVERI/KRUPP REAKTORBAU GMBH, MANNHEIM, GERMANY.**
Gas-cooled high-temperature reactor, 17: 11998 (AEC-tr-5484)
**BROWN UNIV., PROVIDENCE.**
Prog. rpt. on cosmic ray and microbeam effects on skin, 1–12/62, 17: 10363 (TID-17676)
Theory of nucleon-nucleon scattering in strip approximation, 17: 11498 (UCRL-10028)
**BRUSH BERYLLIUM CO., CLEVELAND.**
Prog. rpt. on intermetallic compounds, 1–3/62, 17: 11082 (BBC-113)
**BRUSSELS. CENTRE D'ÉTUDE DE L'ÉNERGIE NUCLÉAIRE.**
Characteristics of neutron beams from BR2, 17: 12022 (BLG-147)
Modification of U isotope in irradiation, 17: 11253 (BLG-140)
Prog. rpt. on in-pile behavior of plutoniferous materials, 4–6/62, 17: 11271 (EURAEC-410)
Prog. rpt. on use of Pu as reactor fuel, 1–3/62, 17: 10249 (EURAEC-301)
Prog. rpt. on use of Pu as reactor fuel, 1–4/62, 17: 11108 (EURAEC-307)
Thermal expansion of $UO_2$, $PuO_2$, and $UO_2$–$PuO_2$, 17: 11203 (EURAEC-434)
**BRUSSELS. SOCIÉTÉ D'ÉTUDES, DE RECHERCHES ET D'APPLICATIONS POUR L'INDUSTRIE.**
Coating uraniferous ceramic particles with Nb, 17: 11116 (EURAEC-487)
Prog. rpt. on coating of uraniferous ceramic particles with Nb, 4–6/62, 17: 11112 (EURAEC-409)
Prog. rpt. on corrosion of steels, 6/16–9/30/62, 17: 11134 (EURAEC-474)
**BRUSSELS. UNIVERSITÉ.**
Prog. rpt. on chemical analysis of products concerning nuclear chemistry, 4–6/62, 17: 10541 (EURAEC-400)
Prog. rpt. on oxidation problems in metals, 7–10/62, 17: 11135 (EURAEC-483)
Prog. rpt. on use of Pu as reactor fuel, 1–4/62, 17: 11108 (EURAEC-307)
**BUREAU OF MINES, ALBANY, ORE.**
Thermodynamic properties of Y and Fe pentacarbonyl, 17: 10580 (BM-RI-6155)
**BUREAU OF MINES, TUSCALOOSA, ALA.**
Thermodynamic properties of Cs chloride and iodide, 17: 10584 (BM-RI-6157)

## C

**CALIFORNIA INST. OF TECH., PASADENA.**
Radial magnet alignment method, 17: 11786 (CTSL-36)
**CALIFORNIA RESEARCH CORP., RICHMOND.**
Prog. rpt. on radiation stability of organic fluids, 17: 11268 (TID-16999)
**CALIFORNIA. UNIV., BERKELEY.**
Anomalous quadrupole coupling in Eu ethylsulfate, 17: 11647 (UCRL-10202)
Consecutive-reaction model systems, 17: 10610 (UCRL-10575)
Crystal structure of $KH_3F_4$, 17: 10608 (UCRL-10197)
Excitation function for $C^{13}(\pi^-,\pi^-n)C^{12}$ reaction, 17: 11648 (UCRL-10312)
Nuclear reactions induced by pions and protons, 17: 11650 (UCRL-10531)
**CALIFORNIA. UNIV., BERKELEY. ELECTRONICS RESEARCH LAB.**
Plasma confinement of EM waves, 17: 11828 (AFCRL-62-63)
**CALIFORNIA. UNIV., BERKELEY. INST. OF ENGINEERING RESEARCH.**
Problems in thermoviscoelasticity, 17: 11338 (UCRL-13059)
**CALIFORNIA. UNIV., BERKELEY. LAWRENCE RADIATION LAB.**
Anomalous quadrupole coupling in Eu ethylsulfate, 17: 11647 (UCRL-10202)
Cement for low-background counting facility, 17: 11903 (UCRL-10475)
Complex angular momentum in many-channel potential-scattering problems. II., 17: 11501 (UCRL-10209)
Consecutive-reaction model systems, 17: 10610 (UCRL-10575)
Crystal structure of $KH_3F_4$, 17: 10608 (UCRL-10197)

Crystal structure of $\beta'$ $Cu_{0.72}Al_{0.28}$, 17: 11195 (UCRL-9536)
Current-switching circuitry, 17: 10918 (UCRL-9035(Rev.))
Deformation of polycrystalline LiF, 17: 11197 (UCRL-10435)
Description of Berkeley 88-inch cyclotron, 17: 11808 (UCRL-10081)
Dislocation concepts of strain rate effects, 17: 11198 (UCRL-10498)
Effects of ion hydration in solvent extraction, 17: 10751 (UCRL-10505)
Electron-energy distribution in H with magnetic fields, 17: 11839 (UCRL-10366)
Energy conversion apparatus in photosynthesis, 17: 10257 (UCRL-10549)
Energy exchange between cold gas and hot tungsten surface, 17: 10609 (UCRL-10504)
Excitation function for $C^{12}(\pi^-,\pi^-n)C^{11}$ reaction, 17: 11648 (UCRL-10312)
Extraction of acids by basic organic solvents. I., 17: 10750 (UCRL-10063)
Four-pion resonance and decay modes of $\rho$ and $\omega$ mesons, 17: 11499 (UCRL-10089(Rev.))
Kinetic energy release in deuteron fission of U-238, 17: 11646 (UCRL-10193)
Mean life of $\pi^0$ meson, 17: 11500 (UCRL-10118(Rev.))
Neutron dosimetry by nuclear track emulsion, 17: 10868 (UCRL-9967 (Rev.))
Neutron emission by Dy-156, Tb-153, and Tb-157 compound nuclei, 17: 11645 (UCRL-10099)
Nuclear reactions induced by pions and protons, 17: 11650 (UCRL-10531)
Plastic behavior of polycrystalline aggregates, 17: 1196 (UCRL-10152)
Project Logic planning, 17: 11073 (UCRL-10491)
Radiation field around high-energy accelerators, 17: 11809 (UCRL-10163)
Spontaneous fission of heavy isotopes, 17: 11649 (UCRL-10481)
Status report of LRL, 1962, 17: 10248 (UCRL-Pub-42)
Theory of nucleon-nucleon scattering in strip approximation, 17: 11498 (UCRL-10028)
Thermodynamic functions for solids from dissociation pressure data, 17: 10607 (UCRL-10189)

**CALIFORNIA. UNIV., LA JOLLA.**
Theory of nucleon-nucleon scattering in strip approximation, 17: 11498 (UCRL-10028)

**CALIFORNIA. UNIV., LIVERMORE. LAWRENCE RADIATION LAB.**
Bremsstrahlung from proton-nucleus collisions, 17: 11644 (UCRL-7001)
Calculating amplitude of refraction arrival, 17: 11337 (UCRL-7146)
Classical systems of charged particles, 17: 11497 (UCRL-6450-T (Rev.I))
Closed extensions of second order, 17: 11072 (UCRL-6648-T)
Collector anodes in gas-flow G-M counter, 17: 11013 (UCRL-6845)
Critical-size calculations for neutron systems, 17: 11462 (UCRL-6707)
Effect of band structure on thermionic emission, 17: 11336 (UCRL-6820)
HARC and HEART THROB—programs for temperature distributions, 17: 10606 (UCRL-7069)
Plutonium alpha air monitor, 17: 11012 (UCRL-6692)
Problems in thermoviscoelasticity, 17: 11338 (UCRL-13059)
Proton scattering by Ni-64 and Zn-64, 17: 11643 (UCRL-6930)
Status report of LRL, 1962, 17: 10248 (UCRL-Pub-42)
Summation counter for detecting weak signals, 17: 10917 (UCRL-6832)
Thermal conductivity and expansion of Pt alloys, 17: 11199 (UCRL-13061)
TORY-IIA—nuclear ramjet test reactor, 17: 11990 (UCRL-5484(Del.))

**CAMBRIDGE ELECTRON ACCELERATOR, MASS.**
Electron beam intensity and position measurement at CEA, 17: 11797 (TID-16967)

**CARNEGIE INST. OF TECH., SAXONBURG, PENNA. NUCLEAR RESEARCH CENTER.**
Prog. rpt. on high-energy nuclear physics, 11/61–10/62, 17: 11331 (TID-17023)

**CAROLINAS VIRGINIA NUCLEAR POWER ASSOCIATES, INC., CHARLOTTE, N. C.**
Prog. rpt. on CVTR project, 5/62, 17: 11996 (WCAP-4125)
Prog. rpt. on CVTR project, 11/62, 17: 11997 (WCAP-4131)

**CENTRAL UTILITIES ATOMIC POWER ASSOCIATES.**
Rod burnout heat flux tests for Pathfinder, 17: 11977 (ACNP-62028)

**CENTRO INFORMAZIONI STUDI ESPERIENZE, MILAN.**
Prog. rpt. on application of steam–$H_2O$ spray to reactor cooling, 7–9/62, 17: 11941 (EURAEC-475)
Prog. rpt. on application of steam–$H_2O$ spray to reactor cooling, 7–9/62, 17: 11942 (EURAEC-476)

**CHICAGO. UNIV.**
Branch point trajectories in complex angular momentum plane, 17: 11495 (TID-17731)
New mesons and resonances in strong interaction physics, 17: 11496 (TID-17742)

**CHICAGO. UNIV. AIR FORCE RADIATION LAB.**
Blood vessels of irradiated rats, 17: 10485 (NP-12251(p.99-113))
Influence of chemical agents on irradiated enzyme, 17: 10480 (NP-12251(p.22-33))
Influence of chemical agents on radiation lethality, 17: 10481 (NP-12251(p.34-46))
Prog. rpt. on radiobiology, 10/62, 17: 10477 (NP-12251)
Radiation effects on thiophosphate-oxidizing enzyme system, 17: 10478 (NP-12251(p.1-11))
Radiation effects on pyridine nucleotide-linked dehydrogenases activity, 17: 10479 (NP-12251(p.12-21))
Radioprotective effects of cyanide and nitriles, 17: 10482 (NP-12251 (p.47-66))
Radioprotective effects of p-aminopropiophenone, 17: 10483 (NP-12251 (p.67-89))
Toxicity of rare earth compounds, 17: 10484 (NP-12251(p.90-8))

**CHICAGO. UNIV. ENRICO FERMI INST. FOR NUCLEAR STUDIES.**
Branch point trajectories in complex angular momentum plane, 17: 11495 (TID-17731)
New mesons and resonances in strong interaction physics, 17: 11496 (TID-17742)

**CHILE. UNIVERSIDAD, SANTIAGO.**
Absorption factor in KI, 17: 11622 (NP-12439)

**COLUMBIA UNIV., NEW YORK.**
Nuclear reactions in Sc-45 and Ti-47, 17: 11624 (NYO-10386)

**COMBUSTION ENGINEERING, INC., WINDSOR, CONN.**
Economics of powder packed fuel elements, 17: 11142 (CEND-153 (Vol.1)(p.3-10))
Fabrication of $UO_2$ elements by "vibswage" process, 17: 11150 (CEND-153(Vol.I)(p.137-47))
Pneumatic vibratory compaction of $UO_2$, 17: 11145 (CEND-153(Vol.I) (p.45-59))
Symposium on powder-packed $UO_2$ fuel elements, 11/30–12/1/61, 17: 11141 (CEND-153(Vol.I))
Symposium on powder packed $UO_2$ fuel elements, 11/30–12/1/61, 17: 11153 (CEND-153(Vol.II))

**COMPAGNIE GÉNÉRALE DE TÉLÉGRAPHIE SANS FIL, PARIS.**
Prog. rpt. on sintering of $UO_2$, 6/60, 17: 11107 (EURAEC-5(Rev.))

**COMPAGNIE INDUSTRIELLE DES COMBUSTIBLES ATOMIQUES FRITTES, CORBEVILLE, PAR ORSAY (SEINE-ET-OISE), FRANCE.**
Chemical properties of extruded $UO_2$, 17: 11160 (CEND-153(Vol.II) (p.131-4))
Extrusion of $UO_2$, 17: 11159 (CEND-153(Vol.II)(p.115-29))
Prog. rpt. on nuclear fuel, 4–6/62, 17: 11111 (EURAEC-407)
Prog. rpt. on nuclear fuel, 1–9/62, 17: 11967 (EURAEC-499)

**COMPAGNIE PECHINEY, PARIS.**
Prog. rpt. on Zr alloys, 7–9/62, 17: 11204 (EURAEC-444)

**COMPAGNIE POUR L'ÉTUDE ET LA RÉALISATION DE COMBUSTIBLES ATOMIQUES, BONNEUIL-SUR-MARNE, FRANCE.**
Prog. rpt. on nuclear fuel, 12/15/61–3/31/62, 17: 11109 (EURAEC-338)
Prog. rpt. on nuclear fuel, 4–6/62, 17: 11111 (EURAEC-407)
Prog. rpt. on nuclear fuel, 1–9/62, 17: 11967 (EURAEC-499)

**CONSOLIDATED EDISON CO. OF NEW YORK, INC.**
Hazards report on Ravenswood nuclear generating unit A, 17: 10858 (NP-12466(Vol.I))
Hazards report on Ravenswood nuclear generating unit A, 17: 10859 (NP-12466(Vol.II))
Hazards report on Ravenswood nuclear generating unit A, 17: 10860 (NP-12466(Vol.III))
Site data on Ravenswood nuclear generating unit A, 17: 10861 (NP-12467)

**CORNELL UNIV., ITHACA, N. Y.**
Prog. rpt. on fission product metabolism, 4/62–1/63, 17: 10310 (TID-17789)

## D

**DEL ELECTRONICS CORP., MOUNT VERNON, N. Y.**
Prog. rpt. on stratospheric monitoring, 4–7/62, 17: 10902 (NYO-9676)
**DENVER. UNIV. DENVER RESEARCH INST.**
Intermediate phases of intm-rare-earth binary systems, 17: 11186 (DRI-2080)
**DIVISION OF REACTOR DEVELOPMENT, AEC.**
Meeting on calcination and fixation of high level wastes, 17: 12044 (TID-7646)
Reactors in U.S., 17: 11957 (TID-8200(7th Rev.))
**DIVISION OF TECHNICAL INFORMATION EXTENSION, AEC.**
Bibliography on failure of reactor fuels, 17: 11956 (TID-3573)
**DOW CHEMICAL CO. ROCKY FLATS DIV., DENVER.**
Shipping radioactive materials, 17: 10862 (RFP-290)
**DU PONT DE NEMOURS (E. I.) & CO. ATOMIC ENERGY DIV., WILMINGTON, DEL.**
Prog. rpt. on heavy water reactors, 11/62, 17: 11979 (DP-805)
**DU PONT DE NEMOURS (E. I.) & CO. METALS CENTER, BALTIMORE.**
Prog. rpt. on Nb alloy extrusion, 10/15/62–1/15/63, 17: 11140 (AMC-TR-7-775(VII))
**DU PONT DE NEMOURS (E. I.) & CO. SAVANNAH RIVER LAB., AIKEN, S. C.**
Control of H in fabrication of $UO_2$ fuels, 17: 11158 (CEND-153(Vol.II) (p.101-14))
Effects of neutron rethermalization in $D_2O$ coolants, 17: 11962 (TID-17574)
Failures of $UO_2$ fuel tubes, 17: 11157 (CEND-153(Vol.II)(p.77-99))
**DU PONT DE NEMOURS (E. I.) & CO. SAVANNAH RIVER PLANT, AIKEN, S. C.**
Plutonium urinalysis procedure, 17: 10527 (ANL-6637(p.33-42))
**DUQUESNE LIGHT CO., SHIPPINGPORT, PENNA.**
Prog. rpt. on environmental radiation monitoring, 7–9/62, 17: 10867 (TID-17769)

## E

**EINDHOVEN, NETHERLANDS. TECHNISCHE HOGESCHOOL.**
Prog. rpt. on heat transfer and stability in BWR, 4–7/62, 17: 11980 (EURAEC-414)
**ELECTRO-OPTICAL SYSTEMS, INC., PASADENA, CALIF.**
Prog. rpt. on radiation-resistant solar cell, 12/62, 17: 10777 (NP-12474)
**EUROPEAN COMPANY FOR THE CHEMICAL PROCESSING OF IRRADIATED FUELS, MOL, BELGIUM.**
Density measurement by $\beta$ and absorption, 17: 10901 (NP-12390)
Determining TBP content of kerosene-based extraction, 17: 10536 (NP-12398)
**EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH, GENEVA.**
Fermion Regge poles, 17: 11466 (CERN-62-33)
Formula translation and combinatorial systems, 17: 11064 (CERN-62-35)

## F

**FIAT. SEZIONE ENERGIA NUCLEARE, TURIN.**
Cold swaging of $UO_2$, 17: 11152 (CEND-153(Vol.I)(p.163-9))
Prog. rpt. on hot channel and hot spot calculation, 7–9/62, 17: 11943 (EURAEC-500)
Prog. rpt. on swaging $UO_2$, 7/61–6/62, 17: 11164 (EURAEC-412)
**FORD INSTRUMENT CO., LONG ISLAND CITY, N. Y.**
Prog. rpt. on thermionic converters, 3/1–6/1/62, 17: 11295 (AD-277713)
**FRANCE. CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, PARIS.**
Prog. rpt. on corrosion of stainless steels, 7–10/62, 17: 11115 (EURAEC-482)
**FRANCE. COMMISSARIAT À L'ÉNERGIE ATOMIQUE, PARIS.**
Annual rpt., 1961, 17: 10241 (NP-12324)
Prog. rpt. on forming and irradiation of UC, 4–6/62, 17: 11110 (EURAEC-387)
Prog. rpt. on shaping and irradiation of UC, 7–9/62, 17: 11114 (EURAEC-477)
Prog. rpt. on shaping and irradiation of UC, 12/15/60–12/15/61, 17: 11118 (EURAEC-496)
Prog. rpt. on sintered $UO_2$, 4–6/62, 17: 11084 (EURAEC-388)
**FRANCE. COMMISSARIAT À L'ÉNERGIE ATOMIQUE. CENTRE D'ÉTUDES NUCLÉAIRES, GRENOBLE.**
Prog. rpt. on hydrodynamic instabilities of BWR, 6–9/62, 17: 11966 (EURAEC-465)
Thermal energy of nuclear origin, 17: 11619 (CEA-2172)
**FRANCE. COMMISSARIAT À L'ÉNERGIE ATOMIQUE. CENTRE D'ÉTUDES NUCLÉAIRES, SACLAY.**
Excited states in N-14, 17: 11623 (NP-12496)
Iodine-131 stopping, 17: 10844 (CEA-Bib-29)
Permissible performance limits of fuel elements in graphite–$CO_2$ reactors, 17: 11999 (AEC-tr-5610)
Thermal absorption and scattering cross sections of natural Ne, 17: 11620 (EANDC(E)-10.U)
Thermal energy of nuclear origin, 17: 11619 (CEA-2172)
**FRANCE. SERVICE CENTRAL DE PROTECTION CONTRE LES RAYONNEMENTS IONISANTS, PARIS.**
Report of activities, 9/62, 17: 10864 (SCPRI(RM)62-9))
Report of activities, 10/62, 17: 10865 (SCPRI(RM)62-10)
**FRANKFORD ARSENAL, PHILADELPHIA.**
Penetration effects in magnetic-dipole L-shell internal conversion, 17: 11618 (BNL-6647)
**FRANKLIN INST., PHILADELPHIA.**
Development of gas-lubricated bearings, 17: 10782 (TID-17756)
Prog. rpt. on gas-lubricated bearings for turbomachinery, 6–8/62, 17: 10781 (TID-17311)
Shipping containers for radioactive materials. L, 17: 10780 (NYO-9859)

## G

**GENERAL ATOMIC DIV., GENERAL DYNAMICS CORP., SAN DIEGO, CALIF.**
Activity analysis GAIL III-A fuel element, 17: 11944 (GAMD-3378)
Boron carbide–graphite nuclear control-rod material, 17: 11085 (GA-3064)
Carbon transport and corrosion in GCR, 17: 11981 (GA-2630)
Flat-plate solar thermoelectric conversion panels, 17: 11300 (ASD-TDR-62-214)
Helium inleakage through fuel elements, 17: 11189 (GAMD-2638)
Prog. rpt. on rare earths in meteorites, 3/15/62, 17: 10821 (GA-2985)
**GENERAL DYNAMICS/CONVAIR, SAN DIEGO, CALIF.**
Prog. rpt. on radiation-resistant pneumatic power system, 9–12/62, 17: 10744 (GDC-63-001)
**GENERAL DYNAMICS/FORT WORTH. DIV. OF GENERAL DYNAMICS CORP., FORT WORTH, TEX.**
Beta and $\alpha$ activity in urine, 17: 10525 (ANL-6637(p.23-8))
Energy and angular distribution experiment. I., 17: 11900 (NARF-62-16T)
Energy storage mechanism in liquid hydrogen, 17: 11262 (NARF-62-15T)
Flight-vehicle power-utilization systems, 3/21/61–6/30/62, 17: 12033 (ASD-TDR-62-591)
TORY-IIA effluent sampling progrm, 17: 11953 (NARF-61-45R)
**GENERAL ELECTRIC CO. AIRCRAFT NUCLEAR PROPULSION DEPT., CINCINNATI.**
SCRAMBLE—for simulation of peripheral equipment on IBM 1401, 17: 11074 (XDC-61-5-2)
**GENERAL ELECTRIC CO. AIRCRAFT NUCLEAR PROPULSION DEPT., IDAHO FALLS, IDAHO.**
Final report on SL-1 recovery, 17: 11983 (IDO-19311)
**GENERAL ELECTRIC CO. ATOMIC POWER EQUIPMENT DEPT., SAN JOSE, CALIF.**
Performance of compacted powder $UO_2$ fuel rods, 17: 11156 (CEND-153 (Vol.II)(p.67-76))
Prog. rpt. on HPD project, 7–9/62, 17: 11945 (GEAP-4096)
Prog. rpt. on two-phase pressure losses, 8–11/62, 17: 10792 (GEAP-4148)
Thermocouple type detector for in-core power monitoring, 17: 10940
**GENERAL ELECTRIC CO. FLIGHT PROPULSION LAB. DEPT., CINCINNATI.**
Prog. rpt. on high-temperature materials, 1/25/63, 17: 11087 (GEMP-19A)
Prog. rpt. on maritime nuclear steam generator, 1/31/63, 17: 11982

(GEMP-175)
Prog. rpt. on refractories, 10–12/62, 17: 11191 (NP-12483)
**GENERAL ELECTRIC CO. GENERAL ENGINEERING LAB., SCHENECTADY, N. Y.**
Influence of liquid viscosity on flooding in vertical tube, 17: 10788 (62GL132)
**GENERAL ELECTRIC CO. HANFORD ATOMIC PRODUCTS OPERATION, RICHLAND, WASH.**
Active metal reduction of $PuCl_3$, 17: 10582 (HW-SA-1973)
Air and gas cleaning operations, 17: 10846 (HW-61840)
Anion exchange of anionic chloro complexes of hexavalent actinides, 17: 10585 (HW-SA-2596)
Application to $UO_3$ calciner furnace of closed loop control system, 17: 10723 (HW-SA-2433)
Atmospheric physics, 17: 10848 (HW-73337(p.1-28))
Chemical effluents technology, 17: 10851 (HW-73337(p.158-237))
Coincidence-count $\alpha$ particulate air monitor, 17: 10532 (HW-SA-2554)
Complex formation by actinide elements in fused KCL–$AlCl_3$ solvents, 17: 10586 (HW-SA-2597)
Conservation of He by radioactive Ar measurements, 17: 11948 (HW-SA-2584)
Critical mass experiments with $Pu(NO_3)_4$, 17: 11459 (HW-SA-2432(Rev.))
Device for recording fuel element dimensions, 17: 10893 (HW-75746)
Effect of base cation on Cs kinetics of clinoptilolite, 17: 10583 (HW-SA-2452)
Effectiveness of high coagulant feed in reducing reactor effluent radioisotope concentrations, 17: 12041 (HW-SA-2192)
Eigenvalue matrix solution to N-component neutron interaction problems, 17: 11458 (HW-75887)
Emergency planning for radiation accident, 17: 10855 (HW-SA-2609)
Evolution of $UO_3$ structure during irradiation of fuel rods, 17: 11260 (HW-SA-2650)
Fabrication of packed-powder fuels, 17: 11143 (CEND-153(Vol.I)(p.11-21))
Factors modifying absorption and retention of ingested Sr-90, 17: 10306 (HW-SA-2577)
Fission product and waste packaging, 17: 12040 (HW-74712)
Hazards of shipping radionuclides, 17: 10853 (HW-SA-2518)
Heat transfer for out-of-reactor cooling of PRTR fuel elements, 17: 10793 (HW-72097(Rev.))
Immiscibility gap in LiCl–KCl–$AlCl_3$, 17: 10587 (HW-SA-2621)
Improved methods for work in radiation zones in production reactors, 17: 10854 (HW-SA-2565)
Instrumentation, 17: 10852 (HW-73337(p.238-97))
Irradiation testing of powder-containing fuel, 17: 11154 (CEND-153 (Vol.II)(p.3-38))
Measurement of cylindrical shapes, 17: 11259 (HW-71521(Rev.))
Mitotic inhibition following x irradiation, 17: 10359 (HW-SA-2606)
Packing of spheres for maximum density, 17: 11088 (HW-73057)
pH control by ion exchange in high pH systems, 17: 10499 (HW-SA-2595)
Piping autoradiography, 17: 11004 (HW-SA-2651)
Prog. rpt. on physics, 7–9/62, 17: 11303 (HW-75228)
Prog. rpt. on radiological research, 1–12/61, 17: 10847 (HW-73337)
Radiological chemistry, 17: 10850 (HW-73337(p.77-157))
Radiological monitoring of ground $H_2O$, 17: 10822 (HW-SA-2566)
Radiological physics, 17: 10849 (HW-73337(p.29-76))
Rate of etching and roughness of cathodically etched metal surfaces, 17: 11089 (HW-SA-2559)
Reactor data logging systems, 17: 11946 (HW-SA-2549)
Scattering law for light water, 17: 11589 (HW-75526)
Scintillating glasses for $\alpha$ counting, 17: 11003 (HW-72512)
Solvent extraction of Cs by dipicrylamine, 17: 10731 (HW-SA-2620)
Spectrophotometric determination of Np, 17: 10533 (HW-SA-2657)
System transfer functions by statistical methods, 17: 11947 (HW-SA-2558)
Thermal conductivity of $UO_2$, 17: 11258 (HW-69945)
Ultrasonic Lamb-wave propagation models for nondestructive testing, 17: 11304 (HW-75499)
Upstream boiling burnout, 17: 10794 (HW-73902(Rev.))
Weldability of metals, 17: 11166 (HW-SA-2527)
X-ray diffraction of irradiated fuel, 17: 10894 (HW-SA-2616)
**GENERAL ELECTRIC CO. MISSILE AND SPACE DIV., VALLEY FORGE SPACE TECHNOLOGY CENTER, KING OF PRUSSIA, PENNA.**
Primary proton protection, 17: 11898 (N62-10900(Pt.III))
**GENERAL ELECTRIC CO. MISSILE AND SPACE VEHICLE DEPT., PHILADELPHIA.**
Primary proton protection, 17: 11899 (N62-10900(Pt.IV))
**GENERAL ELECTRIC CO. RESEARCH LAB., SCHENECTADY, N. Y.**
Kinetics of low source reactor startups. I., 17: 11960 (TID-16142(Pt.I))
Kinetics of low source reactor startups, 17: 11961 (TID-16142(Pt.II))
**GENERAL ELECTRIC CO. SPACECRAFT DEPT., CINCINNATI.**
Prog. rpt. on alkali metals boiling, 7–9/62, 17: 11098 (NP-12433)
**GENERAL ELECTRIC CO. VALLECITOS ATOMIC LAB., SAN JOSE, CALIF.**
Particle size in packing of $UO_2$, 17: 11147 (CEND-153(Vol.I)(p.75-83))
Prog. rpt. on high performance $UO_2$ program, 1–3/62, 17: 11086 (GEAP-3771-4)
**GENERAL MOTORS CORP. DEFENSE RESEARCH LABS., SANTA BARBARA, CALIF.**
Oceanographic literature of Santa Barbara channel area, 17: 10826 (TID-17722)
**GENERAL NUCLEAR ENGINEERING CORP., DUNEDIN, FLA.**
Fabrication of superheater fuel assembly, 17: 11165 (GNEC-179)
Power Reactor Technology, Vol.6, No.1, 17: 12009
**GENERAL TELEPHONE AND ELECTRONICS LABS. INC., PALO ALTO, CALIF.**
Final rpt. on energy transfer in plasma, 17: 11836 (RADC-TDR-62-186)
**GEORGE WASHINGTON UNIV., WASHINGTON, D. C.**
Effects of x irradiation on thymidine incorporation, 17: 10486 (TID-15931)
**GEOTECHNICAL CORP., GARLAND, TEX.**
Seismic measurements of Cimarron, 17: 10242 (NP-12339)
Seismic measurements of Stillwater, 17: 10244 (NP-12444)
Seismic measurements of Armadillo, 17: 10823 (NP-12445)
Seismic measurements of New Madrid earthquake, 17: 10825 (NP-12465)
**GHENT. RIJKSUNIVERSITEIT.**
Prog. rpt. on welding very thick steel plates, 17: 11171 (EURAEC-330)

## H

**HUGHES RESEARCH LABS. DIV. OF HUGHES AIRCRAFT CO., MALIBU, CALIF.**
Prog. rpt. on $H_2^+$ dissociation, 1/63, 17: 10604 (TID-17724)

## I

**ILLINOIS INST. OF TECH., CHICAGO.**
Vapor-liquid equilibrium in $BrF_3$–$UF_4$ system, 17: 10595 (TID-15770)
**ILLINOIS INST. OF TECH., CHICAGO. ARMOUR RESEARCH FOUNDATION.**
Final rpt. on neutron interactions in matter, 17: 10880 (ARF-1164-27)
Prog. rpt. on reactor containment, 8/60–1/61, 17: 11937 (ARF-4132-16)
Prog. rpt. on 2400°F forging die system, 9–12/62, 17: 11081 (ASD-TR-7-886(Vol.VII))
**ILLINOIS. UNIV., CHICAGO.**
Intragastric irradiation with $Ra$–$Rb^{86}$, 17: 10367 (TID-17727)
**ILLINOIS. UNIV., URBANA.**
Liquid He cooled tilting stage for electron microscope, 17: 10914 (TID-17744)
Meson production in interactions of protons with emulsion, 17: 11611 (AD-277387)
Prog. rpt. on bubble motion in turbulent liquid stream, 9–12/62, 17: 10803 (TID-17719)
Prog. rpt. on computers, 10–11/62, 17: 11071 (TID-17810)
Prog. rpt. on digital computers, 9/62, 17: 11069 (TID-17551)
Properties of He-3, 17: 10603 (TID-17721)
Rapid beam ejector at Cosmotron, 17: 11785 (BNL-6678)
Speed-independent logic for control, 17: 11070 (TID-17653)
**ILLINOIS. UNIV., URBANA. ENGINEERING EXPERIMENT STATION.**
Prog. rpt. on high-density plasmas, 9/15–12/15/61, 17: 11826 (AD-273961)
**INSTITUT PASTEUR, PARIS.**
Prog. rpt. on radiation effects on genetic materials, [1962], 17: 10364

(TID-17690)

**INSTITUTE FOR ADVANCED STUDY, PRINCETON, N. J.**
Shell model analysis of the level structure of Ar-41, 17: 11626 (PUC-1962-89)

**ISRAEL. ATOMIC ENERGY COMMISSION, REHOVOTH.**
Analytical aspects of delayed neutron emission, 17: 10534 (IA-784)
Anion exchange of metal complexes. VIII., 17: 10588 (IA-764)
Anion exchange of metal complexes. IX., 17: 10732 (IA-779)

**ITALY. COMITATO NAZIONALE PER L'ENERGIA NUCLEARE. LABORATORI NAZIONALI, FRASCATI.**
Classification of lepton currents, 17: 11479 (LNF-62/98)
Damping constants of electron oscillations in synchrotron, 17: 11787 (LNF-62/96)
Electronic loading of resonant cavity of accelerators, 17: 11792 (RT/EL(62)15)
Higher symmetry for EM and weak transitions, 17: 11477 (LNF-62/94)
Linear polarization of photons in multi-Bev region, 17: 10896 (LNF-62/107)
Muon capture in H, 17: 11480 (LNF-62/109)
Phase discriminator for tuning cavity resonator, 17: 11791 (RT/EL(62)14)
Space charge limited currents in superfluid He, 17: 11312 (LNF-62/106)
Two neutrinos, 17: 11478 (LNF-62/97)

**ITEK LABS., PALO ALTO, CALIF.**
Prog. rpt. on Vela Uniform program, 11/61–4/62, 17: 10819 (AD-278217)

## J

**JOHANN-WOLFGANG-GOETHE-UNIVERSITÄT, FRANKFURT AM MAIN. INSTITUT FÜR KERNPHYSIK.**
Construction of gas scintillation counter, 17: 11005 (IKF-5)
Detection of particles associated with d-d gas target, 17: 11467 (IKF-4)
Effects of delayed neutrons on distribution curve of reactor, 17: 11949 (IKF-2)
Neutron flux and radiation intensity at FRF, 17: 12023 (IKF-1)
Testing of simple model for a BWR, 17: 12024 (IKF-3)

**JOHNS HOPKINS UNIV., BALTIMORE.**
Interfacial reactions with reference to metal corrosion, 17: 10601 (TID-15942)
Neutron spectroscopy, 17: 11638 (TID-17720(p.38-61))
Neutrons from reaction $F^{19}(d,n)Ne^{20}$, 17: 11636 (TID-17720(p.8-14))
Nuclear polarization in $B^{11}(d,p)B^{12}$, 17: 11637 (TID-17720(p.15-37))
Polarization of protons from $B^{11}(d,p)B^{12}$, 17: 11639 (TID-17720(p.62-78))
Production of polarized beams using metastables, 17: 11640 (TID-17720 (p.79-89))
Prog. rpt. on nuclear reactions in light nuclei, 9/62, 17: 11635 (TID-17720)
Search for lepton, 17: 11642 (TID-17720(p.98-100))
Test of Feynmann–Gell-Mann theory of $\beta$-decay, 17: 11641 (TID-17720 (p.90-7))

**JOINT INST. FOR NUCLEAR RESEARCH, DUBNA, U.S.S.R.**
Dispersion relations in quantum electrodynamics, 17: 11468 (JINR-D-1108)
Estimate of virtual number of events, 17: 11475 (JINR-P-1085)
Extrapolation of experimentally determined relationships, 17: 11472 (JINR-P-1046)
Infrared singularities and Regge trajectories in electrodynamics, 17: 11470 (JINR-E-1116)
Interpretation of high-energy neutrino experiments, 17: 11471 (JINR-E-1120)
Parameters of generalized nuclear diffraction model, 17: 11307 (JINR-P-1009)
Radiative corrections in neutron decay, 17: 11469 (JINR-E-1100)
Radiography of spontaneous nuclear fission, 17: 10535 (JINR-P-1118)
Reaction $\pi + N \rightarrow \pi + \gamma + N$, 17: 11476 (JINR-P-1111)
Regge poles and perturbation theory. II., 17: 11905 (JINR-E-1095)
Separation of Fm and Md, 17: 10735 (JINR-P-1075)
Solution of kinetic equations, 17: 11308 (JINR-P-1113)
Statistical background of resonant states, 17: 11474 (JINR-P-1079)
Transfer reactions in Th irradiation by Ne-22, 17: 11473 (JINR-P-1071)

## K

**KAISER ENGINEERS. DIV. OF HENRY J. KAISER CO., OAKLAND, CALIF.**
Control rod worth for EGCR, 17: 11958 (TID-11601)
Fuel assembly and heat transfer for EGCR. I., 17: 11989 (TID-11604)

**KERNFORSCHUNGSZENTRUM, KARLSRUHE, GERMANY.**
Resolving power and solid angle of particle spectrometers. I., 17: 10895 (KFK-113)

**KERNREAKTOR BAU- UND BETRIEBS-GESELLSCHAFT M.B.H., KARLSRUHE, GERMANY.**
Resolving power and solid angle of particle spectrometers. I., 17: 10895 (KFK-113)

**KNOLLS ATOMIC POWER LAB., SCHENECTADY, N. Y.**
Abundance of 1.43-Mev $\gamma$ ray of Cs-138, 17: 11621 (KAPL-M-HME-6)
Cascade mass spectrometer, 17: 10909 (TID-15951)
Corrosion in energy conversion systems, 17: 11133 (TID-16561)
Corrosion rate of preoxidized Zy-2, 17: 11132 (KAPL-M-AA-4)
Eddy current testing. I. Theory, 17: 10815 (TID-16062)
HAFMAT—steady-state flow distribution program, 17: 10798 (KAPL-M-LKW-1)
HOTSTICK—KARE axial power distribution program for Philco 2000, 17: 11951 (KAPL-M-RPC-5)
Kinetics of low source reactor startups. I., 17: 11960 (TID-16142(Pt.I))
Kinetics of low source reactor startups, 17: 11961 (TID-16142(Pt.II))
KWIP—kinetics with plotter, 17: 11950 (KAPL-M-EC-28)
Measurement of two ion currents by pulse counting in mass spectrometer, 17: 10908 (TID-15865)
Neutron captures in U-235 and natural B, 17: 11629 (TID-15884)
Nondestructive testing of welds, 17: 11168 (TID-15756)
Pulsed electrostatic analyzer for ion energy determinations, 17: 11010 (TID-16311)
$THD_3$—temperature distribution in slab with internal heat generation, 17: 10797 (KAPL-M-EC-27)
Thermocouples for temperature measurements of Zy-2 weldments, 17: 11105 (TID-17734)
360° Tandem mass spectrometer, 17: 10912 (TID-16312)

**KOREA. OFFICE OF ATOMIC ENERGY, SEOUL.**
Safeguards against radiation hazards, 17: 10857 (NP-12427)

## L

**LABORATOIRE D'INFRA-ROUGE TECHNIQUE ET APPLIQUÉ, GIF-SUR-YVETTE, FRANCE.**
Edge emission of CdS bombarded by electrons, 17: 11317 (NP-12322)

**LIBRARY OF CONGRESS. AIR INFORMATION DIV., WASHINGTON, D. C.**
Nuclear instrumentation and control for propulsion, 17: 10889 (AD-252467)

**LONDON. ROYAL CANCER HOSPITAL.**
Cell population studies on intestine of irradiated rats, 17: 10355 (BNL-6113)

**LONDON. UNIV. UNIVERSITY COLL.**
Positron elastic scattering by atomic H, 17: 11328 (TID-15769)

**LOS ALAMOS SCIENTIFIC LAB., N. MEX.**
Fluid dynamics and particle-and-force models, 17: 11310 (LA-2806)
Modification of momentum region in Thomas-Fermi theory, 17: 11309 (LA-2750)
Prog. rpt. on plasma thermocouple program, 10/62, 17: 11311 (LAMS-2796)
Prog. rpt. on thermonuclear research, 11/20/62, 17: 11831 (LAMS-2816)
Prog. rpt. on UHTREX, 10–12/62, 17: 11984 (LAMS-2835)
RATH mesher—program for heat conduction codes, 17: 10799 (LAMS-2809)
Reactor irradiation of U-impregnated graphite, 17: 11261 (LAMS-2814)
Solution of general least squares problem, 17: 11065 (LA-2367(Add.))
Thermodynamic functions for Pu, 17: 10593 (LA-2813)

**LOVELACE FOUNDATION FOR MEDICAL EDUCATION AND RESEARCH, ALBUQUERQUE, N. MEX.**
Cascade impactor operating at low volumetric flow rates, 17: 10775 (LF-5)
Nuclear bomb effects computer, 17: 10845 (CEX-62.2)

## M

**MAINE. UNIV., ORONO.**
Association constants of Cd and Cl ions in $NH_3$, 17: 10594 (TID-15741)
**MARTIN-MARIETTA CORP. AEROSPACE DIV., BALTIMORE.**
PM-3A hazards report corrections, 17: 11985 (MND-M3A-2496(Vol.I) (Add.))
Prog. rpt. on thermionic power generator, 11/62–1/63, 17: 11313 (MND-2945-1)
**MASCHINENFABRIK AUGSBURG-NÜRNBERG A. G., NUREMBERG.**
Prog. rpt. on critical boiling $H_2O$ burnout, 6–8/62, 17: 10807 (EURAEC-449)
**MASSACHUSETTS INST. OF TECH., CAMBRIDGE.**
Absorption studies in 8-quinolinol family, 17: 10667 (TID-15433)
Deuteron stripping in Coulomb field, 17: 11630 (TID-15924)
Fluoride complexes of Hf, 17: 10600 (TID-15939)
Ion exchange in PyHCL–NaCl–Dowex-50, 17: 10747 (TID-15923)
Measuring electron-ionization cross sections, 17: 11319 (NP-12358)
Neutron kinetics and cross sections in fast non-moderating assemblies, 17: 11598 (TID-16304)
Prog. rpt. on mineral engineering problems, 5–10/62, 17: 11091 (MITS-49)
**MELLON INST., PITTSBURGH.**
Lattice parameters in tetragonal metals and alloys, 17: 11330 (TID-16045)
**MICHIGAN. UNIV., ANN ARBOR.**
Gnome seismogram album, 17: 10824 (NP-12462)
Prog. rpt. on 83-inch cyclotron, 10–12/62, 17: 11806 (TID-17735)
**MINNESOTA. UNIV., MINNEAPOLIS.**
Noise properties of gas discharges. I., 17: 11829 (ASD-TR-61-179 (Vol.I))
**MOL, BELGIUM. CENTRE D'ÉTUDE DE L'ÉNERGIE NUCLÉAIRE.**
Prog. rpt. on retreatment of irradiated fuels, 7–8/62, 17: 10519 (EURAEC-460)
Prog. rpt. on swelling of U, 7–9/62, 17: 11257 (EURAEC-464)
**MONTEFIORE HOSPITAL, NEW YORK.**
Distribution and excretion of radioactive rare earth compounds, 17: 10308 (TID-17542)
**MOUND LAB., MIAMISBURG, OHIO.**
Prog. rpt. on research, 8/62, 17: 10239 (MLM-1140)
**MSA RESEARCH CORP., CALLERY, PENNA.**
Final rpt. on decontamination of radioactive components, 17: 12042 (MSAR-61-34)

## N

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION. GODDARD INST. FOR SPACE STUDIES, NEW YORK.**
Origin of atmospheric Xe, 17: 11445 (NASA-TN-D-1685)
**NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.**
Determination of $\beta$-emitting radionuclides in aqueous formamide, 17: 10526 (ANL-6637(p.29-31))
**NATIONAL LEAD CO. OF OHIO, CINCINNATI.**
Carrier distillation of impurities in $U_3O_8$, 17: 10538 (TID-16295)
**NAVAL CIVIL ENGINEERING LAB., PORT HUENEME, CALIF.**
Blast-closure valve, 17: 10776 (NP-12454)
Differential dose albedo for $\gamma$ rays on concrete, 17: 11901 (NP-12455)
**NAVAL RADIOLOGICAL DEFENSE LAB., SAN FRANCISCO.**
Compensating for temperature dependence of monitoring system, 17: 11014 (USNRDL-TR-604)
Photomicrographic technique for measuring grain densities of $\beta$ particle tracks, 17: 10919 (USNRDL-TR-591)
Scintillation system for inspection of W billets, 17: 10816 (USNRDL-TR-602)
System for rapid handling of irradiated solution, 17: 10784 (USNRDL-TR-601)
Thermal diffusivity and heat capacity measurements, 17: 11200 (USNRDL-TR-599)
**NAVAL RESEARCH LAB., WASHINGTON, D. C.**
Bibliography on direct energy conversion, 17: 11322 (NP-12429)
**NETHERLANDS. NIJVERHEIDSORGANISATIE, TNO, THE HAGUE.**
Prog. rpt. on ductile-brittle transition temperature of steel, 7–9/62, 17: 11187 (EURAEC-447)
**NEW BRUNSWICK LAB., AEC, N. J.**
Separation and determination of Pu in Pu–U fuel elements, 17: 10737 (NBL-189)
**NEW MEXICO. UNIV., ALBUQUERQUE.**
Construction and evaluation of 3-dimensional strain rosette, 17: 10783 (TID-17773)
**NEW YORK OPERATIONS OFFICE. HEALTH AND SAFETY LAB., AEC.**
Criticality and criticality control, 17: 10528 (ANL-6637(p.43-57))
Determining Ra-226 in soil samples, 17: 10531 (ANL-6637(p.97-9))
Radium-226 in diet in U. S. cities, 17: 10530 (ANL-6637(p.85-95))
Urine U excretion data, 17: 10305 (HASL-120)
**NEW YORK. STATE DEPT. OF HEALTH, ALBANY.**
Environmental levels of Ra, 17: 10529 (ANL-6637(p.59-84))
**NEW YORK. STATE UNIV., ALBANY. RESEARCH FOUNDATION.**
Prog. rpt. on antibody formation, 4/62–3/63, 17: 10255 (TID-17648)
**NEW YORK. STATE UNIV. VETERINARY COLL., ITHACA.**
Prog. rpt. on fission product metabolism, 4/62–1/63, 17: 10310 (TID-17789)
**NEW YORK UNIV., NEW YORK.**
Binding studies of rare earths to proteins and nucleic acids, 12/61–11/62, 17: 10307 (TID-17522)
Computation of hydrodynamic flows, 17: 11324 (NYO-9603)
**NEW YORK UNIV., NEW YORK. ATOMIC ENERGY COMMISSION COMPUTING AND APPLIED MATHEMATICS CENTER.**
Finite difference schemes for equations hydrodynamics, 17: 11323 (NYO-9188)
**NEW ZEALAND. INST. OF NUCLEAR SCIENCES, LOWER HUTT.**
Annual report, 3/61–2/62, 17: 10243 (NP-12381)
**NORDISK INSTITUT FOR TEORETISK ATOMFYSIK, COPENHAGEN.**
Analytic properties of S matrix in perturbation theory, 17: 11483 (NP-12436)
Groups and their applications to spectroscopy, 17: 11906 (NP-12434)
Many-body problems, 17: 11481 (NP-12435(Pt.I))
Many-body problems, 17: 11482 (NP-12435(Pt.II))
**NORTH AMERICAN AVIATION, INC., DOWNEY, CALIF.**
Electromagnetic levitation of U, 17: 11092 (NAA-SR-Memo-615)
**NORTH CAROLINA STATE COLL., RALEIGH.**
Neutron transport theory, 17: 11592 (NP-12480)
**NORTHERN STATES POWER CO., MINNEAPOLIS.**
Rod burnout heat flux tests for Pathfinder, 17: 11977 (ACNP-62028)
**NORTHROP CORP. NORTHROP SPACE LABS., HAWTHORNE, CALIF.**
Hazards rpt. for Northrop reactor, 17: 12025 (NP-12299)
**NORTHWESTERN UNIV., EVANSTON, ILL.**
System to obtain higher space resolution in nuclear emulsions, 17: 11333 (TID-17640)
**NUCLEAR MATERIALS AND EQUIPMENT CORP., APOLLO, PENNA.**
Producing spherical Be particles, 17: 11101 (NUMEC-P-49)
**NUCLEAR METALS, INC., CONCORD, MASS.**
Prog. rpt. on metallurgy, 11/62, 17: 11093 (NMI-2112)
Prog. rpt. on metallurgy, 12/62, 17: 11094 (NMI-2113)
**NUCLEAR METALS, INC., WEST CONCORD, MASS.**
Prog. rpt. on power reactors, 8/62, 17: 11095 (NMI-7254)
Prog. rpt. on power reactors, 10/62, 17: 11096 (NMI-7256)
Prog. rpt. on power reactor program, 11/62, 17: 11097 (NMI-7257)
**NUKLEARNI INSTITUT "JOSEF STEFAN," LJUBLJANA, YUGOSLAVIA.**
Fuel element fabrication of $UO_2$ powders, 17: 11149 (CEND-153(Vol.I) (p.125-35))

## O

**OAK RIDGE GASEOUS DIFFUSION PLANT, TENN.**
Critical interaction potentials of $H_2O$-moderated $UF_6$ arrays, 17: 11460 (TID-17633)
Flow and separation in gas centrifuge, 17: 11053 (TID-15764)
Separation of isotopes by gaseous diffusion, 17: 11052 (TID-15348)
Thermal diffusion column performance, 17: 11051 (TID-15343)
**OAK RIDGE INST. OF NUCLEAR STUDIES, INC., TENN.**
Conference on nuclear education, Gatlinburg, 8/62, 17: 10247 (TID-7638)
**OAK RIDGE NATIONAL LAB., TENN.**
Body burden of Pu from urinalysis data, 17: 10524 (ANL-6637(p.13-21))

Buckling of initially out-of-round tubes subjected to external pressure, 17: 11192 (ORNL-3299)
CASPER: program for plotting and scaling data, 17: 11066 (ORNL-3394)
Chemical physics, 17: 10514 (ORNL-3320(p.104-25))
Chemical separation of isotopes, 17: 10508 (ORNL-3320(p.22-9))
Chemistry of aqueous systems, 17: 10511 (ORNL-3320(p.56-82))
Compacted powder fuel irradiation studies, 17: 11155 (CEND-153 (Vol.II)(p.39-65))
Comparison of DBPP and DSBPP with TBP for recovery of U and Th, 17: 10738 (ORNL-3374)
Computer calculations for loss-of-power in EGCR, 17: 11987 (ORNL-TM-476)
Conference on nuclear education, Gatlinburg, 8/62, 17: 10247 (TID-7638)
DCX-2 performance curves, 17: 11835 (ORNL-3387)
Electrochemical kinetics and application to corrosion, 17: 10512 (ORNL-3320(p.83-97))
Electronic accounting devices for data logging, 17: 10903 (ORNL-TM-344)
IBM-7090 subroutine package for making logarithmic and semilogarithmic graphs, 17: 11067 (ORNL-TM-430)
Isolation of synthetic elements, 17: 10507 (ORNL-3320(p.16-21))
Nonaqueous systems at high temperature, 17: 10513 (ORNL-3320(p.98-103))
Nuclear chemistry, 17: 10506 (ORNL-3320(p.1-15))
Organic chemistry, 17: 10510 (ORNL-3320(p.47-55))
Preparation of oxide fuels for vibratory compaction, 17: 11144 (CEND-153(Vol.I)(p.23-38))
Processing of decayed Zr–U alloy fuel, 17: 10742 (ORNL-TM-447)
Prog. rpt. on chemical development, 7–9/62, 17: 10246 (ORNL-TM-403)
Prog. rpt. on chemistry, 6/20/62, 17: 10505 (ORNL-3320)
Prog. rpt. on chemical technology, 8–9/61, 17: 10739 (ORNL-TM-27)
Prog. rpt. on chemical technology, 1–3/62, 17: 10740 (ORNL-TM-181)
Prog. rpt. on chemical technology, 6/62, 17: 10741 (ORNL-TM-313)
Prog. rpt. on chemical technology, 1/61, 17: 10743 (ORNL-TM-457)
Prog. rpt. on gas-cooled reactors, 9/30/62, 17: 11955 (ORNL-3372)
Proton scattering by Ni-64 and Zn-64, 17: 11643 (UCRL-6930)
Radiation chemistry, 17: 10509 (ORNL-3320(p.30-46))
Reduced pressure backflow preventer, 17: 10515 (ORNL-3380)
Space vehicle shielding, 17: 11902 (ORNL-3317)
Star density produced by 24-Bev proton beam in heavy concrete, 17: 11489 (ORNL-3367)
Thermal and radiation stability of alternative gas coolants, 17: 10516 (ORNL-TM-475)
Vibratory-compaction studies at ORNL, 17: 11146 (CEND-153(Vol.I)(p.61-74))

**OHIO STATE UNIV. RESEARCH FOUNDATION, COLUMBUS.**
Prog. rpt. on nuclear physics, final, 11/50–9/62, 17: 11633 (TID-17534)

**OKLAHOMA STATE UNIV., STILLWATER.**
Fluoride complexes of Hf, 17: 10600 (TID-15939)

**OREGON STATE UNIV., CORVALLIS.**
Neutron cross sections and nuclear spectroscopy, 17: 11627 (TID-15088)

**ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, PARIS.**
Bibliography on decontamination of radioactive $H_2O$, 17: 12043 (NP-12482)

**OWENS-CORNING FIBERGLAS CORP. TECHNICAL CENTER, GRANVILLE, OHIO.**
Radioactive fuel-bearing glasses, 17: 11102 (NYO-9735)

## P

**P.E.C. CORP., BOULDER, COLO.**
Prog. rpt. on photo processes, 9–11/62, 17: 10681 (TID-17743)

**PENNSYLVANIA STATE UNIV., UNIVERSITY PARK.**
Prog. rpt. on fused salts, 8/16/62–12/31/62, 17: 10518 (TID-17823)
Solid-phase reactions at high pressures, 17: 10503 (NP-12359)

**PITTSBURGH. UNIV.**
Magnetic characteristics of hydrogenated Ho, 17: 10599 (TID-15935)
Magnetic characteristics of Gd, Tb and Y hydrides, 17: 11329 (TID-15934)
Prog. rpt. on nuclear reactions, 1/9/62–1/9/63, 17: 11634 (TID-17696)

**POLISH ACADEMY OF SCIENCES. INST. OF NUCLEAR PHYSICS, KRAKOW.**
Scattering of deuterons on Al-27 nuclei, 17: 11625 (PAN-204)

**POLISH ACADEMY OF SCIENCES. INST. OF NUCLEAR RESEARCH. WARSAW.**
Effects of radiation on aliphatic polyethers, 17: 10678 (PAN-306/XVII)
Fast neutrons elastically scattered on Ca, 17: 11593 (PAN-354/I-A)
Synthesis of $C^{14}$-labeled methylamine hydrochloride, 17: 10517 (PAN-336/XIII)

**POLISH ACADEMY OF SCIENCES. INST. OF PHYSICS, WARSAW.**
Planck's constant and theory of red shift, 17: 11305 (IFT-1)

**PRATT AND WHITNEY AIRCRAFT DIV., UNITED AIRCRAFT CORP., HARTFORD, CONN.**
Supercritical water reactor shield, 17: 11988 (PWAC-100)

**PRINCETON–PENNSYLVANIA ACCELERATOR, PRINCETON, N. J.**
Magnet systems design, 17: 11790 (PPAD-459F)

**PRINCETON UNIV., N. J.**
Angular distribution of $K_{\mu 3}$ decay products, 17: 11484 (NP-12460)
Evaluation of Kadomtsev's theory of plasma turbulence, 17: 11833 (MATT-114)
Ion energy analyzer for plasma measurements, 17: 10897 (MATT-121)
Magnet systems design, 17: 11790 (PPAD-459F)
Shell model analysis of the level structure of Ar-41, 17: 11626 (PUC-1962-89)
Stability of stellarator, 17: 11788 (MATT-119)
Theory of irreversible processes, 17: 11832 (MATT-106)
Velocity-dependent interaction between natural clocks and distant matter, 17: 11325 (PUC-1962-68)

**PUBLIC HEALTH SERVICE, WASHINGTON, D. C.**
Factors influencing Sr-90 in milk, 17: 10352

## R

**RADIATION APPLICATIONS INC., LONG ISLAND CITY, N. Y.**
Prog. rpt. on transparent plastic moisture barriers, 17: 10666 (RAI-303)

**RAND CORP., SANTA MONICA, CALIF.**
Problems in mathematics of multiple scattering, 17: 11490 (RM-3221-PR)

**RENSSELAER POLYTECHNIC INST., TROY, N. Y.**
Dislocation mobility and interactions in Mg, 17: 11182 (AROD-3394.1)
Non-aqueous conductance data, 17: 10504 (NYO-9696)
Prog. rpt. on linear accelerator project, 10–12/62, 17: 11805 (TID-17728)
Prog. rpt. on plasma physics, 5–10/61, 17: 11834 (NP-12367)
Transients in pulsed moderators, 17: 11597 (TID-16085)
Treatment of asymmetric thin regions, 17: 11596 (TID-15752)

**REPUBLIC AVIATION CORP. MISSILE SYSTEMS DIV., MINEOLA, N. Y.**
Space power system technology, 17: 12035 (NP-12492)

**RESEARCH CHEMICALS. DIV. OF NUCLEAR CORP. OF AMERICA, PHOENIX, ARIZ.**
Rare earth chalcogenides, 9/60–6/61, 17: 11292 (AD-277043)

**RIO DE JANEIRO. CENTRO BRASILEIRO DE PESQUISAS FISICAS.**
Decay $\Sigma^0 \rightarrow \Lambda^0 + \gamma$ in charge-independent $\pi$ interaction, 17: 11488 (NP-12499)
Excited states in N-14, 17: 11623 (NP-12496)
Production and spin of $K^0$ resonance, 17: 11487 (NP-12488)

**ROCHESTER, N. Y. UNIV.**
Design of quadrupole channel, 17: 11789 (NYO-10251)

**ROCKETDYNE DIV., NORTH AMERICAN AVIATION, INC., CANOGA PARK, CALIF.**
Final rpt. on propulsion of ion bombardment type, 3/15/61–3/15/62, 17: 11302 (ASD-TR-61-150(Pt.II))

**ROME. UNIVERSITÀ.**
Proton-recoil counter exposed to neutron source, 17: 11002 (CNEN-158)

## S

**SAINT PROCOPIUS COLL., LISLE, ILL.**
Construction of muscle-equivalent environmental radiation meter, 17: 11011 (TID-17824)

**SANDIA CORP., ALBUQUERQUE, N. MEX.**
Average neutron energy of reactor spectra, 17: 11594 (SCTM-205-62(53))
Characteristics of linear variable differential transformer gage head,

17: 10904 (SCTM-100-62-81)
Construction and evaluation of 3-dimensional strain rosette, 17: 10783 (TID-17773)
Determination of Cr, Co, Fe, and Ni in alloys, 17: 10539 (TID-16296)
Electrical noise in instrumentation systems, 17: 10915 (TID-17749)
Ergodic transformations, 17: 11068 (TID-15948)
High repetition rate blocking oscillator, 17: 10906 (TID-15312)
High-voltage pulse resistors, 17: 10905 (SCTM-230-62(14))
Low-pressure spall thresholds in Cu, 17: 11326 (SC-4747(RR))
Mass-spectrometer gas analysis, 17: 10537 (TID-15724)
Phantom gage, 17: 10913 (TID-17740)
Portable radiac equipment at Sandia, 17: 11007 (TID-15765)
Radiation damage to semiconductor devices, 17: 11267 (TID-15959)

**SÃO PAULO, BRAZIL. UNIVERSIDADE.**
Prog. rpt. on genetic effects of radiation, 1/63, 17: 10256 (TID-17699)

**SOCIÉTÉ BELGE POUR L'INDUSTRIE NUCLÉAIRE, BRUSSELS.**
Prog. rpt. on in-pile behavior of plutoniferous materials, 7–9/62, 17: 11117 (EURAEC-491)
Prog. rpt. on in-pile behavior of plutoniferous materials, 4–6/62, 17: 11271 (EURAEC-410)
Prog. rpt. on use of Pu as reactor fuel, 1–3/62, 17: 10249 (EURAEC-301)
Prog. rpt. on use of Pu as reactor fuel, 1–4/62, 17: 11108 (EURAEC-307)
Thermal expansion of $UO_2$, $PuO_2$, and $UO_2$–$PuO_2$, 17: 11203 (EURAEC-434)

**SOCIÉTÉ DES FORGES ET ATELIERS DU CREUSOT, PARIS.**
Prog. rpt. on embrittlement of welded steel joints, 4–6/62, 17: 11113 (EURAEC-430)

**SOUDOMETAL, S. A., BRUSSELS.**
Prog. rpt. on welding very thick steel plates, 17: 11171 (EURAEC-330)

**SOUTHERN RESEARCH INST., BIRMINGHAM, ALA.**
Prog. rpt. on high-strength and heat-resistant alloys, 4–6/62, 17: 11075 (AD-278043)
Thermal conductivity and expansion of Pt alloys, 17: 11199 (UCRL-13061)

**STANFORD RESEARCH INST., MENLO PARK, CALIF.**
Prog. rpt. on oxidation and nitridation of Nb, 17: 10602 (TID-16820)
Prog. rpt. on sorption of gases on metal surfaces, 8/15–11/15/62, 17: 11193 (TID-17635)

**STANFORD UNIV., CALIF.**
Design of magnetic momentum slits, 17: 11796 (SLAC-6)
Dynamics of particle in field of tapered solenoid, 17: 11795 (SLAC-4)
Focusing for Stanford two-mile accelerator, 17: 11793 (SLAC-2)
Geomagnetic field and solar corpuscular radiation, 17: 11449 (ML-975)
Prog. rpt. on accelerator project, 1–3/58, 17: 11798 (TID-17221)
Prog. rpt. on plasma oscillations, 3–5/62, 17: 11838 (TID-16990)
Shower development and heating in waveguide structure with 800-Mev electron beam, 17: 11794 (SLAC-3)

**STICHTING INSTITUUT VOOR KERNPHYSISCH ONDERZOEK, AMSTERDAM.**
Prog. rpt. for 1961, 17: 10240 (NP-12208)

**STICHTING VOOR FUNDAMENTEEL ONDERZOEK DER MATERIE, UTRECHT.**
Prog. rpt. for 1961, 17: 10240 (NP-12208)

**SWEDEN. KUNGLIGA VETENSKAPSAKADEMIEN. NOBELINSTITUTET FOR FYSIK, STOCKHOLM.**
Nuclear reactions induced by heavy ion bombardment, 17: 11612 (AFOSR-2975)

## T

**TAPCO. DIV. OF THOMPSON RAMO WOOLDRIDGE INC., CLEVELAND.**
Tungsten emitters for ion propulsion systems, 17: 11080 (ASD-TDR-62-756)

**TEMPLE UNIV., PHILADELPHIA.**
Prog. rpt. on metal ions dissolved in inorganic salts, 1/63, 17: 10605 (TID-17816)

**TEXAS. UNIV., AUSTIN.**
Prog. rpt. on radiation effects on bacteria, 7/53–9/62, 17: 10366 (TID-17697)

**THOMPSON PRODUCTS, INC., CLEVELAND.**
SNAP II power conversion system CRU design, 17: 11986 (NAA-SR-6307)

**TRACERLAB, INC., WALTHAM, MASS.**
Prog. rpt. on detection of radiation in static and flowing liquid H, 7–9/61, 17: 10900 (NP-12363)
Prog. rpt. on effects of radiation on liquid H medium, 17: 11264 (NP-12388)

## U

**UNION CARBIDE NUCLEAR CO. Y-12 PLANT, OAK RIDGE, TENN.**
Excretion of U from mixed exposures, 17: 10311 (Y-KB-1)
Salt bath heat transfer rates for U, 17: 10805 (Y-1410)
Short-arc welding of Hastelloy N (INOR-8), 17: 11169 (Y-1409)
Statistics in health physics, 17: 10869 (Y-KB-7)

**UNITED ELECTRODYNAMICS, INC., ALEXANDRIA, VA.**
Seismic measurements of Dormouse Prime, 17: 11321 (NP-12418)

**UNITED KINGDOM ATOMIC ENERGY AUTHORITY. AUTHORITY HEALTH AND SAFETY BRANCH, RISLEY, LANCS, ENGLAND.**
Safe handling of Zr and Zr alloys, 17: 10863 (RSPP-20(Issue 1))

**UNITED KINGDOM ATOMIC ENERGY AUTHORITY. REACTOR GROUP, SPRINGFIELDS, LANCS, ENGLAND.**
Oxides based upon CaO and BeO, 17: 11194 (TRG-Report-408)

**UNITED KINGDOM ATOMIC ENERGY AUTHORITY. RESEARCH GROUP. ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL, BERKS, ENGLAND.**
Apparatus for cylindrical graphite specimens, 17: 11934 (AERE-R-3453)
Chemical methods of radiation dosimetry, 17: 10998 (AERE-R-4198)
Creep properties of Mg–Cd alloy, 17: 11179 (AERE-M-1149)
Fluorescent decay of anthracene, 17: 10671 (AERE-M-1153)
Heat and mass transfer between solid wall and fluid stream, 17: 10790 (AERE-R-4197)

**UNITED KINGDOM ATOMIC ENERGY AUTHORITY. WEAPONS GROUP. ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKS, ENGLAND.**
Equation of state of U in critical region, 17: 11183 (AWRE-O-61/62)

**UNITED NUCLEAR CORP. DEVELOPMENT DIV., WHITE PLAINS, N. Y.**
Description of SORTIE I code, 17: 11591 (NP-12370)
Prog. rpt. on fuel cycle development, 7–9/62, 17: 11106 (UNC-5040)
Wet steam as reactor coolant, 17: 11965 (UNC-5008-I)

**UNITED STATES–EURATOM JOINT RESEARCH AND DEVELOPMENT PROGRAM.**
Coating uraniferous ceramic particles with Nb, 17: 11116 (EURAEC-487)
Prog. rpt. on application of steam–$H_2O$ spray to reactor cooling, 7–9/62, 17: 11941 (EURAEC-475)
Prog. rpt. on application of steam–$H_2O$ spray to reactor cooling, 7–9/62, 17: 11942 (EURAEC-476)
Prog. rpt. on chemical analysis of products concerning nuclear chemistry, 4–6/62, 17: 10541 (EURAEC-400)
Prog. rpt. on coating of uraniferous ceramic particles with Nb, 4–6/62, 17: 11112 (EURAEC-409)
Prog. rpt. on corrosion of stainless steels, 7–10/62, 17: 11115 (EURAEC-482)
Prog. rpt. on corrosion of steels, 6/16–9/30/62, 17: 11134 (EURAEC-474)
Prog. rpt. on critical boiling $H_2O$ burnout, 6–8/62, 17: 10807 (EURAEC-449)
Prog. rpt. on ductile-brittle transition temperature of steel, 7–9/62, 17: 11187 (EURAEC-447)
Prog. rpt. on embrittlement of welded steel joints, 4–6/62, 17: 11113 (EURAEC-430)
Prog. rpt. on forming and irradiation of UC, 4–6/62, 17: 11110 (EURAEC-387)
Prog. rpt. on heat transfer and stability in BWR, 4–7/62, 17: 11980 (EURAEC-414)
Prog. rpt. on high performance $UO_2$ program, 1–3/62, 17: 11086 (GEAP-3771-4)
Prog. rpt. on hot channel and hot spot calculation, 7–9/62, 17: 11943 (EURAEC-500)
Prog. rpt. on hydrodynamic instabilities of BWR, 6–9/62, 17: 11966 (EURAEC-465)
Prog. rpt. on in-pile behavior of plutoniferous materials, 7–9/62, 17: 11117 (EURAEC-491)
Prog. rpt. on in-pile behavior of plutoniferous materials, 4–6/62,

17: 11271 (EURAEC-410)
Prog. rpt. on nuclear fuel, 12/15/61–3/31/62, 17: 11109 (EURAEC-338)
Prog. rpt. on nuclear fuel, 4–6/62, 17: 11111 (EURAEC-407)
Prog. rpt. on nuclear fuel, 1–9/62, 17: 11967 (EURAEC-499)
Prog. rpt. on oxidation problems in metals, 7–10/62, 17: 11135 (EURAEC-483)
Prog. rpt. on radiation effects on pressure vessel steels, 7–9/62, 17: 11188 (EURAEC-485)
Prog. rpt. on retreatment of irradiated fuels, 7–8/62, 17: 10519 (EURAEC-460)
Prog. rpt. on shaping and irradiation of UC, 7–9/62, 17: 11114 (EURAEC-477)
Prog. rpt. on sintered $UO_2$, 4–6/62, 17: 11084 (EURAEC-388)
Prog. rpt. on sintering of $UO_2$, 6/60, 17: 11107 (EURAEC-5(Rev.))
Prog. rpt. on stresses in welding, 4–6/62, 17: 11172 (EURAEC-391)
Prog. rpt. on stresses in welding, 7–9/62, 17: 11173 (EURAEC-446)
Prog. rpt. on swaging $UO_2$, 7/61–6/62, 17: 11164 (EURAEC-412)
Prog. rpt. on swelling of U, 7–9/62, 17: 11257 (EURAEC-464)
Prog. rpt. on use of Pu as reactor fuel, 1–3/62, 17: 10249 (EURAEC-301)
Prog. rpt. on use of Pu as reactor fuel, 1–4/62, 17: 11108 (EURAEC-307)
Prog. rpt. on Zr alloys, 7–9/62, 17: 11204 (EURAEC-444)
Symposium on powder-packed $UO_2$ fuel elements, 11/30–12/1/61, 17: 11141 (CEND-153(Vol.I))
Symposium on powder packed $UO_2$ fuel elements, 11/30–12/1/61, 17: 11153 (CEND-153(Vol.II))
Thermal expansion of $UO_2$, $PuO_2$, and $UO_2$–$PuO_2$, 17: 11203 (EURAEC-434)
Wet steam as reactor coolant, 17: 11965 (UNC-5008-I)

**UTAH. UNIV., SALT LAKE CITY.**
Alpha dose from surface and volume deposits of Pu-239, Th-228, and Ra-226, 17: 10301 (COO-226(p.78-85))
Effects of Ra-226 injections on peripheral blood values of beagle, 17: 10297 (COO-226(p.50-6))
Gingival ulceration induced in beagles, 17: 10296 (COO-226(p.35-49))
Hyperossification in autogenous tibial transplants, 17: 10304 (COO-226(p.128-30))
Injection tables, 17: 10295 (COO-226(p.3-33))
Interlaboratory and interstandard comparisons of Sr-90, 17: 10299 (COO-226(p.66-70))
Long-term effects of Pu-239 in adult beagles, 17: 10303 (COO-226(p.95-127))
Plutonium extraction from biological material, 17: 10298 (COO-226(p.58-65))
Prog. rpt. on radiobiology research, 9/30/62, 17: 10294 (COO-226)
Radium dosimetry, 17: 10302 (COO-226(p.86-94))
Radium studies in man soon after injection, 17: 10300 (COO-226(p.71-77))

## V

**VETERANS ADMINISTRATION HOSPITAL, HINES, ILL.**
Distribution and excretion of radioactive rare earth compounds, 17: 10308 (TID-17542)

**VIENNA. UNIVERSITÄT.**
New resonances, 17: 11464 (AFOSR-2978)

**VIRGINIA. UNIV., CHARLOTTESVILLE.**
Countercurrent flow in semi-infinite gas centrifuge, 17: 11054 (UVA-279-63U)
Countercurrent flow in semi-infinite gas centrifuge, 17: 11055 (UVA-280-63U)

## W

**WARSAW. UNIV.**
Planck's constant and theory of red shift, 17: 11305 (IFT-1)

**WATERTOWN ARSENAL, MASS.**
Observation of $Li^6(n,\alpha)H^3$ reaction, 17: 11615 (BNL-6082)

**WAYNE STATE UNIV., DETROIT.**
Solvent extraction of inorganic ions with surface-active agents, 17: 10749 (TID-17746)
Spectrophotometric determination of Co, 17: 10540 (TID-17745)

**WESTINGHOUSE ELECTRIC CORP., PITTSBURGH.**
Final rpt. on decontamination of radioactive components, 17: 12042 (MSAR-61-34)
Formation of p-n junction by ion bombardment, 17: 10773 (ASD-TDR-62-428)

**WESTINGHOUSE ELECTRIC CORP. ATOMIC POWER DEPT., PITTSBURGH.**
Mixing in flow parallel to rod bundles having square lattice, 17: 10804 (WCAP-1607)

**WESTINGHOUSE ELECTRIC CORP. ATOMIC POWER DIV., PITTSBURGH.**
Prog. rpt. on CVTR project, 5/62, 17: 11996 (WCAP-4125)
Prog. rpt. on CVTR project, 11/62, 17: 11997 (WCAP-4131)

**WESTINGHOUSE ELECTRIC CORP. BETTIS ATOMIC POWER LAB., PITTSBURGH.**
Application of spherical harmonics technique to problems in $\gamma$ transport, 17: 11502 (WAPD-T-1458)
Boron capture fraction measurements in PWR-2 geometry, 17: 11995 (WAPD-T-1371(Rev.))
Criticality predictions of PWR-2 design, 17: 11994 (WAPD-T-1370)
Effects of burnup on oxide ceramic fuels, 17: 11270 (WAPD-T-1455)
Extrapolation lengths in pulsed water systems, 17: 11600 (WAPD-T-1490)
Flow distribution across PWR core, 17: 11992 (WAPD-PWR-TE-93)
Physics tests on PWR-1 Seed 2, 17: 11991 (WAPD-PWR-TE-81)
Power distribution in PWR-2 mockup, 17: 11993 (WAPD-T-1369(Rev.))
Setting neutron current, 17: 11599 (WAPD-T-1457)
Shippingport data acquisition system, 17: 10920 (WAPD-T-1447)

**WESTINGHOUSE ELECTRIC CORP. RESEARCH LABS., PITTSBURGH.**
Prog. rpt. on thermoelectricity, 9–11/61, 17: 11293 (AD-277122)
Prog. rpt. on thermoelectricity, 7–10/61, 17: 11294 (AD-277223)

**WISCONSIN. UNIV., MADISON.**
Evaporation neutrons from protons on Rh, 17: 11631 (TID-16049)
Generalized momentum operators in quantum mechanics, 17: 11339 (WIS-AEC-34)

**WORTHINGTON CORP. ADVANCED PRODUCTS DIV., NEWARK, N. J.**
Prog. rpt. on high-pressure pump seal, 12/61–2/62, 17: 10778 (NYO-9742)
Prog. rpt. on high-pressure pump seal, 3–5/62, 17: 10779 (NYO-9743)

## Y

**YALE UNIV., NEW HAVEN.**
Approximate in scattering theory, 17: 11492 (TID-16044)
Chronic $\gamma$ irradiation of pitch pine-oak forest, 17: 10362 (TID-16254)
Heavy-ion detection system, 17: 11008 (TID-16174)
Prog. rpt. on nuclear researches, 2/61–1/62, 17: 11332 (TID-17590)
Thin films for measurement of charged-particle ranges, 17: 10911 (TID-16251)
Uniformity of commercial foils, 17: 11104 (TID-16252)
Vector mesons and nucleon-nucleon spin-orbit interaction, 17: 11491 (TID-15930)

# PERSONAL AUTHOR INDEX

Each entry after an author's name is a shortened version of the title of the report or article, followed by the *NSA* volume and abstract number. Report numbers are given in parentheses.

The phrase "Progress report" is abbreviated as "Prog. rpt." This change permits a more rapid and complete alphabetical arrangement of the titles without changing the location of the progress report titles in relation to the other titles.

Because of problems involving the mechanical preparation of this index, all accent marks are omitted. The following changes in spelling have been introduced to reduce some of the confusion which might result from omitting the accents:

| | | |
|---|---|---|
| æ | becomes | ae |
| ö | | oe |
| ø | | oe |
| ü | | ue (except in transliterated Chinese names) |

## A


**ABRAMOWITZ, Sol,** Radiopulmonogram, 17: 10280

**ABRAMOWSKI, Peter,** Radiation protection with butazolidine metabolite I Tanderil. I., 17: 10472

**ABSON, W.,** Fission chamber detectors, 17: 10987

**ADAM, A.,** Ionization chamber for fast neutrons, 17: 11035

**ADAMS, J. Barclay,** Neutrino pair emission by stellar plasma, 17: 11446

**ADAMSON, Anne-Marie,** Internal conversion and *L* fluorescence in Pa-234, 17: 11657

**ADDIS, B. F.,** Liquid Bi penetration into boundaries in Ni, 17: 11241

**ADELMAN, M.,** Phase equilibrium for $UO_2(NO_3)_2$–$HNO_3$–$H_2O$, 17: 10615

**ADELMAN, M.,** Phase equilibrium for $UO_2(NO_3)_2$–$Al(NO_3)_3$–$HNO_3$–$H_2O$, 17: 10616

**ADER, Marie,** Effects of Po $\alpha$ radiation on gelatin, 17: 10703

**ADLER, H. I.,** X-ray sensitivity of *E. coli*, 17: 10426

**ADO, Yu. M.,** Coherent electron radiation in synchrotron, 17: 11770 (BNL-767(p.100-5))

**AFANAS'EV, Yu. A.,** Reciprocal effect of Th and Ce nitrates on coextraction with TBP, 17: 10760

**AGAFONOV, V. P.,** Gamma recording by bremsstrahlung beam, 17: 11555

**AGARWAL, Bipin Kumar,** Branching ratios in isobar model for $K^-$-p, 17: 11560

**AGGETT, J.,** Aqueous coordination chemistry of Be, 17: 10498 (AAEC/TM-161)

**AGTE, C.,** Analysis of systems of high-melting carbides, 17: 11201 (AEC-tr-5598)

**AINSLIE, D.,** Postoperative irradiation of corneal grafts, 17: 10439

**AKAGI, Hiroaki,** Neutron dosimetry by nuclear track emulsion, 17: 10868 (UCRL-9967(Rev.))

**AKOPYAN, M. E.,** Photoionization and application in mass spectroscopy, 17: 10567

**ALBARES, D.,** Prog. rpt. on high-density plasmas, 9/15–12/15/61, 17: 11826 (AD-273961)

**ALBERS, C.,** Luminescent properties of CdS single crystals, 17: 10637

**ALBRECHT, G.,** Non-contracting positive column under negative ion effect, 17: 11873

**ALBRECHT, G.,** Theory of contraction of positive columns, 17: 11874

**ALBRIGHT, Ray W.,** Nuclear bomb effects computer, 17: 10845 (CEX-62.2)

**ALBURGER, D. E.,** Helium-3 reactions on B-11 and N-14, 17: 11721

**ALBURGER, D. E.,** Parity of 2.13-Mev first excited state of B-11, 17: 11707

**ALDER, Kurt,** Influence of magnetic dipole electric quadrupole interaction on angular correlations, 17: 11386

**ALEKSEEV (ALEKSEIEV), A. G.,** Characteristics of 4-6 Bev electron synchrotron, 17: 11766 (BNL-767(p.67-74))

**ALESCIO, Tommaso,** Radiation response of mouse embryonic lung, 17: 10420

**ALEXANDER, John M.,** Cross section and recoil studies of proton reactions with U-238, 17: 11726

**ALEXANDER, John M.,** Kinetic energy release in deuteron fission of U-238, 17: 11646 (UCRL-10193)

**ALEXANDER, John M.,** Neutron emission by Dy-156, Tb-153, and Tb-157 compound nuclei, 17: 11645 (UCRL-10099)

**ALEXANDER, N.,** Turnover rate of Zn determined by Zn-65, 17: 10275

**ALEXANDER, R.,** Prog. rpt. on fission product metabolism, 4/62–1/63, 17: 10310 (TID-17789)

**ALFEROVA, V. V.,** Peripheral vessels in persons working on cyclotron, 17: 10444

**ALIAGA-KELLY, D.,** Health physics monitoring instruments, 17: 10960

**ALIKHANOV, S. G.,** Diffusion of plasma in magnetic field, 17: 11881

**ALLEMAN, R. T.,** Radiant spray calcination, 17: 12051 (TID-7646(p.83-93))

**ALPERT, Seymour S.,** Nuclear moments and hfs of Eu-152, 17: 11702

**ALSMILLER, R. G., Jr.,** Space vehicle shielding, 17: 11902 (ORNL-3317)

**ALSMILLER, R. G., Jr.,** Star density produced by 24-Bev proton beam in heavy concrete, 17: 11489 (ORNL-3367)

**ALTERTHUM, H.,** Analysis of systems of high-melting carbides, 17: 11201 (AEC-tr-5598)

**AMBROSE, T. W.,** Heat transfer for out-of-reactor cooling of PRTR fuel elements, 17: 10793 (HW-72097(Rev.))

**AMES, L. L., Jr.,** Chemical effluents technology, 17: 10851 (HW-73337(p.158-237))

**AMES, L. L., Jr.,** Effect of base cation on Cs kinetics of clinoptilolite, 17: 10583 (HW-SA-2452)

**AMIEL, S.,** Analytical aspects of delayed neutron emission, 17: 10534 (IA-784)

**AMSEL, G.,** Mechanism of anodic oxidation, 17: 11138

**ANDERSON, A. C.,** Properties of He-3, 17: 10603 (TID-17721)

**ANDERSON, D. G.,** Glass scintillators, 17: 10965

**ANDERSON, E.,** Prog. rpt. on radiation effects on pressure vessel steels, 7–9/62, 17: 11188 (EURAEC-485)

**ANDERSON, J. K.,** Upstream boiling burnout, 17: 10794 (HW-73902(Rev.))

**ANDERSON, R. W.,** Prog. rpt. on power reactors, 8/62, 17: 11095 (NMI-7254)

**ANDERSON, R. W.,** Prog. rpt. on power reactors, 10/62, 17: 11096 (NMI-7256)

**ANDERSON, R. W.,** Prog. rpt. on power reactor program, 11/62, 17: 11097 (NMI-7257)

**ANDERSSON, I. O.,** Hand monitor for simultaneous measurement, 17: 10962

**ANDERSSON, I. O.,** Measuring radioactivity in the human body, 17: 10963

**ANDRAKO, A. M.,** Corrosion rate of preoxidized Zy-2, 17: 11132 (KAPL-M-AA-4)
**ANDREWS, J. Robert,** Effect of radiation density on reproductive capacity of mammalian tumor cells, 17: 10396
**ANDRIESSEN, H.,** Thermal expansion of $UO_2$, $PuO_2$, and $UO_2$–$PuO_2$, 17: 11203 (EURAEC-434)
**ANDROSENKO, Kh. D.,** Isodose neutron detector, 17: 11034
**ANIANSSON, Gunnar,** Retardation of non-relativistic charged particles, 17: 11341
**ANISIMOV, A. I.,** Diffusion of charged particles in dense plasma, 17: 11880
**ANSELL, G. S.,** Dislocation mobility and interactions in Mg, 17: 11182 (AROD-3394.1)
**ANTHONY, D. J.,** Neutron captures in U-235 and natural B, 17: 11629 (TID-15884)
**APPELMAN, E. H.,** One-electron redox reactions involving destruction of $MO_2^+$ structure, 17: 10596 (TID-15793)
**APPINO, James B.,** Radioisotopic method of evaluating dispersed systems. I., 17: 10884
**ARAJS, Sigurds,** Electric resistivity due to electron-phonon scattering in Y and Lu, 17: 11221
**ARBUZOV, B. A.,** Regge poles and perturbation theory. II., 17: 11905 (JINR-E-1095)
**ARD, W. B.,** Neutron production from D plasma, 17: 11866
**ARDEN, A.,** Development of radiation pneumonitis, 17: 10377
**ARIEL, M.,** Determination of Tl in urine, 17: 10550
**ARIN, M. Louis,** Properties of Be compounds. I., 17: 10627
**ARKERYD, L.,** Cross sections for neutron inelastic scattering and (n,2n) processes, 17: 11587 (AE-88)
**ARLOWE, H. D.,** Electrical noise in instrumentation systems, 17: 10915 (TID-17749)
**ARMSTRONG, P. J.,** Nucleon-nucleon potential of Green, 17: 11527
**ARNIKAR, H.-J.,** Separation of $(n,\gamma)$ recoil products in Br and I, 17: 10702
**ARNOLD, J. S.,** Failure of Pu to deposit in osteoid, 17: 10330
**ARNOLD, J. S.,** Radioautographic distribution of Pu-239, 17: 10329
**ARNOLD, James S.,** Toxicity of Pu in skeletal tissues. I., 17: 10346
**ARON, William,** Oceanographic literature of Santa Barbara channel area, 17: 10826 (TID-17722)
**ARTAMONOVA, S. M.,** Precipitation of certain elements from fused $NH_4NO_3$, 17: 10621
**ARTEM'EV, V. V.,** Data for describing characteristics of radiometric apparatus, 17: 11042
**ARZHANYI, P. M.,** Thermodiffusion in W–Be system, 17: 11214
**ARZUMANOV, A. A.,** Acceleration and extraction of ions in cyclotron, 17: 11778 (BNL-767(p.254-77))
**ASHBY, V. J.,** Lithium-6 and $Li^6(n,2n)$ cross sections, 17: 11722
**ASRIBEKOV, V. E.,** Properties of many-point functions, 17: 11371
**ASTAF'EVA, A. V.,** Solvent extraction of rare earths, 17: 10764
**ASTROEM, Bjoern,** Nuclear reactions induced by heavy ion bombardment, 17: 11612 (AFOSR-2975)
**ATHERTON, D. R.,** Metabolism of Pu-239 in adult beagles, 17: 10319
**ATHERTON, D. R.,** Plutonium extraction from biological material, 17: 10298 (COO-226(p.58-65))
**ATHERTON, David R.,** Interlaboratory and interstandard comparisons of Sr-90, 17: 10299 (COO-226(p.66-70))
**ATWELL, M. G.,** Carrier distillation of impurities in $U_3O_8$, 17: 10538 (TID-16295)
**AUGUST, G.,** Plasma confinement of EM waves, 17: 11828 (AFCRL-62-63)
**AUSTERMAN, Stanley B.,** Growth of BeO single crystals, 17: 11122
**AVANZI, S.,** Radiation and mutagenic agent effects on wheat, 17: 10388
**AYER, Frederick,** Bubble chamber track-centering device, 17: 11000 (BNL-6094)
**AYER, Frederick, II,** Versatile bubble-chamber track measuring stage, 17: 11001 (BNL-6095)
**AZHAZHA, E. G.,** Strontium-90 in Atlantic surface waters, 17: 10835
**AZHGIREI, L. S.,** Parameters of generalized nuclear diffraction model, 17: 11307 (JINR-P-1009)
**AZIMOV, Ya. I.,** Influence of spin on position of Regge poles, 17: 11485 (NP-12478)

## B

**BABAYAN, C. P.,** Energetic particle interactions with atomic nuclei at mountain altitudes, 17: 11454
**BABECKI, J.,** Energetic particle interactions with atomic nuclei at mountain altitudes, 17: 11454
**BACH, D.,** Determination of Tl in urine, 17: 10550
**BACKMAN, G. E.,** Emergency planning for radiation accident, 17: 10855 (HW-SA-2609)
**BADENKO, I. I.,** Monomolecular P-32 source, 17: 10713
**BAEHR, Franz Walter,** Measurement of water flow with radioisotopes. I., 17: 10885
**BAEHR, Franz Walter,** Measurement of water flow with radioisotopes. II., 17: 10886
**BAER, W.,** Boron capture fraction measurements in PWR-2 geometry, 17: 11995 (WAPD-T-1371(Rev.))
**BAER, W.,** Power distribution in PWR-2 mockup, 17: 11993 (WAPD-T-1369 (Rev.))
**BAGDASAR'YAN, Kh. S.,** Formation of amine ion radicals during radiolysis of organic solutions, 17: 10687
**BAGOT, William C.,** Project Logic planning, 17: 11073 (UCRL-10491)
**BAICKER, Joseph A.,** Recombination and trapping in normal and irradiated Si, 17: 11383
**BAIR, W. J.,** Effect of inhaled $Pu^{239}O_2$ on life span of mice, 17: 10323
**BAIR, W. J.,** Retention, translocation, and excretion of inhaled $Pu^{239}O_2$, 17: 10321
**BAIR, W. J.,** Toxicity of inhaled Pu in dogs, 17: 10322
**BAIRD, Justus N., Jr.,** Reduced pressure backflow preventer, 17: 10515 (ORNL-3380)
**BAKER, John Wesley,** Sampling of airborne radioactive particles, 17: 10856 (NP-12351)
**BAKER, W. E.,** Construction and evaluation of 3-dimensional strain rosette, 17: 10783 (TID-17773)
**BAKER, Winslow F.,** Computer program to optimize magnets in beam transport system, 17: 11781 (BNL-6189)
**BAKH, N. A.,** Radiolysis and radiation-induced oxidation of diisopropyl ether, 17: 10705
**BAKULIN, E. A.,** Mobility of Li ions in aqueous $LiNO_3$ solutions, 17: 10659
**BALACHANDRAN, A. P.,** New resonances, 17: 11464 (AFOSR-2978)
**BALDI, L.,** $\beta$-absorption and glass transitions in polymers, 17: 11282
**BALIAN, Roger,** Direct interaction in theory of nuclear reactions, 17: 11669
**BALLAM, J.,** Design of magnetic momentum slits, 17: 11796 (SLAC-6)
**BALLANTINE, D.,** Radiation-induced effects in MgO catalysts, 17: 10672 (BNL-6097)
**BALLARD, G. G.,** Transistors in reactor instrumentation, 17: 10989
**BALLEW, C. W.,** Cascade impactor operating at low volumetric flow rates, 17: 10775 (LF-5)
**BALLOU, J. E.,** Chelating agents for Pu removal, 17: 10334
**BALLOU, J. E.,** Combined toxic effects of Pu plus x-ray, 17: 10318
**BALTZINGER, Christiane,** Cross section and recoil studies of proton reactions with U-238, 17: 11726
**BANDO, Hiroharu,** Collective motion in even-even deformed nuclei, 17: 11732
**BANKER, Gilbert S.,** Radioisotopic method of evaluating dispersed systems. I., 17: 10884
**BARAC, G.,** X-ray effects on bilirubin and biliverdin, 17: 10376
**BARASHENKOV, V. S.,** Elastic interactions of high-energy particles, 17: 11507
**BARBASHOV, B. M.,** Regge poles and perturbation theory. II., 17: 11905 (JINR-E-1095)
**BARBIELLINI, G.,** Linear polarization of photons in multi-Bev region, 17: 10896 (LNF-62/107)
**BARDEEN, John,** Critical fields and currents in superconductors, 17: 11421
**BARGMANN, V.,** Representations of the rotation group, 17: 11569
**BARKAS, Walter H.,** Mean life of $\pi^0$ meson, 17: 11500 (UCRL-10118(Rev.))
**BARNES, John F.,** Modification of momentum region in Thomas-Fermi theory, 17: 11309 (LA-2750)
**BARNES, R. G.,** Nuclear quadrupole interactions and resonance frequencies. I., 17: 10592 (IS-520)
**BARNES, R. K.,** Beta particle thread thickness gage, 17: 10979
**BARR, K. P.,** Power distribution in PWR-2 mockup, 17: 11993 (WAPD-T-1369(Rev.))

**BARRETT, J. H.,** Beta particle thread thickness gage, 17: 10979
**BARSCHALL, H. H.,** Evaporation neutrons from protons on Rh, 17: 11631 (TID-16049)
**BARTLETT, Robert Owen,** Nuclear effect of LiH as propellant in nuclear rocket reactor, 17: 12034 (NP-12353)
**BARTOLI, A. L.,** Space charge limited currents in superfluid He, 17: 11312 (LNF-62/106)
**BARTON, M. Q.,** Rapid beam ejector at Cosmotron, 17: 11785 (BNL-6678)
**BARTSCH, Gunnar,** Segregation of Al–Zn and Al–Cu alloys, 17: 11246
**BARYSHEVA, K. F.,** Solvent extraction of rare earths, 17: 10764
**BASHANDY, E.,** Half life of first excited state in Pr-143, 17: 11689
**BASHKIN, S.,** Bombardment of C-12 by Li-6 ions, 17: 11718
**BASS, F. G.,** Energy losses of charged particles above plasma in vacuum, 17: 11886
**BASTIEN, I. J.,** Phase equilibrium for $UO_2(NO_3)_2$–$HNO_3$–$H_2O$, 17: 10615
**BATCH, J. M.,** Upstream boiling burnout, 17: 10794 (HW-73902(Rev.))
**BATCHELOR, James D.,** Pyrolytic graphite in rocket motors, 17: 11076 (AD-278371)
**BATEMAN, J. L.,** Effects of radiations on early responses in mammal, 17: 10358 (BNL-6575)
**BATSANOV, S. S.,** Atomic radii systematics, 17: 10664
**BATSKIKH (BATSKICH), G. I.,** Electronic systems for proton synchrotron, 17: 11763 (BNL-767(p.32-47))
**BATTY, C. J.,** Polarization in p-p scattering, 17: 11525
**BAUER, Hans,** Spermatocyte division in tuplidae. III., 17: 10402
**BAUMANN, C. G.,** Radiation-induced polymerization of $\alpha$-methylstyrene, 17: 11285
**BAUSA, W. E.,** Steam generators for gas-cooled reactors, 17: 12000
**BAXTER, J. P.,** Lucas Heights research establishment, 17: 10254
**BAYADSYAN, N. G.,** Energetic particle interactions with atomic nuclei at mountain altitudes, 17: 11454
**BAYER, Ryszard,** Gate circuit for pulse analyzers, 17: 11031
**BAYLY, I. L.,** X-ray-induced single-leaf mutation in *Medicago sativa L.*, 17: 10399
**BAYMAN, B. F.,** Groups and their applications to spectroscopy, 17: 11906 (NP-12434)
**BEAN, C. H.,** Vacuum brazing of superheater fuel plates, 17: 11078 (ANL-FGF-329)
**BEARD, E. L.,** Portable DOP tester for inspection of high-efficiency filters, 17: 10922
**BEATTY, Alvin V.,** Chromosomal aberration gradients in Tradescantia anthers, 17: 10454
**BEATTY, Joanne W.,** Chromosomal aberration gradients in Tradescantia anthers, 17: 10454
**BEATTY, R. L.,** Vibratory-compaction studies at ORNL, 17: 11146 (CEND-153(Vol.1)(p.61-74))
**BEAUDOIN, C. L.,** Fuel assembly and heat transfer for EGCR. I., 17: 11989 (TID-11604)
**BEAUMARIAGE, M. L.,** X-ray effects on bilirubin and biliverdin, 17: 10376
**BEAVER, W. W.,** Prog. rpt. on intermetallic compounds, 1–3/62, 17: 11082 (BBC-113)
**BECK, F.,** Remarks on Klein's paradox, 17: 11580
**BECKER, E.,** Cesium-137 in $\gamma$ radiography, 17: 10817
**BECKER, E.,** Handling devices in $\gamma$ radioscopy, 17: 10818
**BECKER, E. W.,** Separation nozzle method with light auxiliary gas, 17: 11062
**BECKER, James F.,** Collector anodes in gas-flow G-M counter, 17: 11013 (UCRL-6845)
**BECKER, Kurt M.,** Burnout conditions for flow of boiling $H_2O$ in vertical annuli, 17: 10789 (AE-100)
**BECKER, L. C.,** Uniformity of commercial foils, 17: 11104 (TID-16252)
**BECKER, M. C.,** Neutron production from D plasma, 17: 11866
**BECKHAM, Walter C.,** Bremsstrahlung from proton-nucleus collisions, 17: 11644 (UCRL-7001)
**BEDNAR, J.,** Hydrogen peroxide formation in $H_2O$ radiolysis, 17: 10686
**BEER, G. A.,** Lattice parameters for NPD and CANDU fuel elements in $D_2O$, 17: 11939 (CRL-75)
**BEGHIAN, L. E.,** Neutron kinetics and cross sections in fast non-moderating assemblies, 17: 11598 (TID-16304)
**BEGUM, R. J.,** Scattering of cold neutrons by BeO, 17: 11671
**BEIER, Gundolf,** Dose distribution in use of oblique tube, 17: 10878
**BEIGEL, Mary,** Environmental levels of Ra, 17: 10529 (ANL-6637(p.59-84))
**BEIL, H.,** Thermal absorption and scattering cross sections of natural Ne, 17: 11620 (EANDC(E)-10.U)
**BELL, J. S.,** Fluctuation compressibility theorem and application to pairing model, 17: 11398
**BELLION, B.,** Evaluation of occupational injury from radiation, 17: 10447
**BELYAKOV, A. M.,** Vanadium and Nb carbides in steel, 17: 11209
**BENCOSME, Sergio A.,** Renal tubular fine structure during U injury, 17: 10265
**BENES, J.,** Luminescence of AgCl crystals, 17: 10712
**BENESOVSKY, F.,** Graphite-coated particle fuel production, 17: 11174
**BENIOFF, Paul A.,** Effect of angular localization on direct nuclear reactions, 17: 11703
**BENNETT, R. L.,** Thermal and radiation stability of alternative gas coolants, 17: 10516 (ORNL-TM-475)
**BENSAID, Nicole,** Protection by cysteine of phosphatase, 17: 10405
**BENSON, G. C.,** Cohesive and surface energies of Th and U dioxides, 17: 11217
**BENTLEY, Donald L.,** Representation for Wald's compartment theory, 17: 11028
**BENTON, E. V.,** Photomicrographic technique for measuring grain densities of particle tracks, 17: 10919 (USNRDL-TR-591)
**BENVENISTE, J.,** Proton scattering by Ni-64 and Zn-64, 17: 11643 (UCRL-6930)
**BENZLER, H.,** Cooling efficiency of gas-cooled reactors, 17: 11969
**BERARD, Michael F.,** Discovery and development of lanthanon rare earths, 17: 10618
**BERDJIS, Charles C.,** Cortisone and radiation. IV., 17: 10470
**BERDJIS, Charles C.,** Virus infection and x radiation, 17: 10427
**BERESTETSKII (BERESTETSKY), V. B.,** Removing ghost on vacuum Regge pole trajectory, 17: 11486 (NP-12479)
**BERGE, Trygve O.,** Virus infection and x radiation, 17: 10427
**BERGEDER, Hans-Dietrich,** Influence on pyruvic acid kinase by radiation-conditioned electrolytic displacement, 17: 10469
**BERGER, Eugene Y.,** Binding studies of rare earths to proteins and nucleic acids, 12/61–11/62, 17: 10307 (TID-17522)
**BERGER, Harold,** Film copying technique for improving radiographic contrast, 17: 10891 (ANL-FGF-339)
**BERGER, Harold,** Neutron radiography, 17: 10814 (ANL-FGF-335)
**BERGER, Harold,** Scintillator-polaroid film camera for neutron image detection, 17: 10999 (ANL-FGF-340)
**BERGER, J.,** Thermal energy of nuclear origin, 17: 11619 (CEA-2172)
**BERGER, Z.,** Luminescence of AgCl crystals, 17: 10712
**BERGQVIST, C. A.,** Xenon predictor for reactors, 17: 10993
**BERGQVIST, I.,** Gamma rays from capture of fast neutrons in Ta, W, Au, Hg, and Pb, 17: 11659
**BERGQVIST, Mats S.,** Proton resonance shifts in $H_2O$–$D_2O$, 17: 11342
**BERGSNOV-HANSEN, Bjoern,** Prog. rpt. on sorption of gases on metal surfaces, 8/15–11/15/62, 17: 11193 (TID-17635)
**BERGSTROEM, Ingmar,** Nuclear reactions induced by heavy ion bombardment, 17: 11612 (AFOSR-2975)
**BERLEY, D.,** Comparison of $\eta$, $\tau$, and $\tau'$ decays, 17: 11553
**BERMAN, A. S.,** Flow and separation in gas centrifuge, 17: 11053 (TID-15764)
**BERMAN, R. M.,** Effects of burnup on oxide ceramic fuels, 17: 11270 (WAPD-T-1455)
**BERNARDINI, C.,** "AdA" accumulator ring for electrons and positrons, 17: 11820
**BERNSTEIN, Jeremy,** Theory of process $p + p \rightarrow d + \omega$, 17: 11465 (BNL-6646)
**BERRY, Roger J.,** Effect of radiation density on reproductive capacity of mammalian tumor cells, 17: 10396
**BERTAUT, E. F.,** Uranates of Co and Mn, 17: 10633
**BERTOZZI, W.,** Polarization of neutrons from photodisintegration of D, 17: 11551
**BETZ, E. H.,** Cystamine protection of irradiated thymocytes, 17: 10487
**BEVILACQUA, Ljerka,** Photorestoration of fragments by irradiated amoeba, 17: 10410
**BEYER, N. S.,** Film copying technique for improving radiographic contrast, 17: 10891 (ANL-FGF-339)
**BEYNAM, E.,** Electromagnetic simulation of point gamma sources, 17: 11503
**BEZINGER, E. N.,** Role of lipoprotein in protein synthesis, 17: 10314

**BEZUGLYI, V. D.,** Scintillation properties of 1,3-oxazole derivatives in polystyrene, 17: 11227
**BHADURI, R. K.,** Nucleon-nucleon potential of Green, 17: 11527
**BHATT, Kumar H.,** Single particle Nilsson model, 17: 11660
**BIALECKE, E.,** Prog. rpt. on high-density plasmas, 9/15–12/15/61, 17: 11826 (AD-273961)
**BIANCHI, A.,** Genetic damage in radiation-treated maize seeds, 17: 10380
**BIANCHI, A.,** X-ray-induced somatic mutations in maize seedlings, 17: 10394
**BIEDENKAPP, D.,** Nuclear quadrupole coupling constants of Na-23, 17: 10646
**BIELSKI, B. H. J.,** Oxidation of $H_2O_2$ by Ce(IV), 17: 10631
**BIEM, W.,** Influence of hard core on f-sum of nuclei, 17: 11753
**BIER, K.,** Separation nozzle method with light auxiliary gas, 17: 11062
**BIER, W.,** Separation nozzle method with light auxiliary gas, 17: 11062
**BINCER, Adam M.,** Momentum dependence of phase shifts and magnitude of coupling constants, 17: 11922
**BINDONI, M.,** Effects of x radiation on urinary excretion, 17: 10463
**BIONDI, Manfred A.,** Mechanism of electron-ion recombination. I., 17: 11384
**BISHOP, A. A.,** Mixing in flow parallel to rod bundles having square lattice, 17: 10804 (WCAP-1607)
**BISHOP, G. H.,** Liquid Bi penetration into boundaries in Ni, 17: 11241
**BISKIS, Birute O.,** Toxicity of Pu in mice, 17: 10317
**BISWAS, M. M.,** Investigations on stone meteorites, 17: 10839
**BIZZARRI, U.,** "AdA" accumulator ring for electrons and positrons, 17: 11820
**BJOERKMAN, J.,** Pulse-counting period meter, 17: 10973
**BLACK, Henry M.,** Thermal efficiency of coated annular fins, 17: 10796 (IS-571)
**BLAKE, C. A., Jr.,** Comparison of DBPP and DSBPP with TBP for recovery of U and Th, 17: 10738 (ORNL-3374)
**BLAKE, Damon D.,** Complications of radiation therapy for cervical carcinoma, 17: 10449
**BLANCO, R. E.,** Pot calcination, 17: 12049 (TID-7646(p.52-68))
**BLANCO, R. E.,** Prog. rpt. on chemical development, 7–9/62, 17: 10246 (ORNL-TM-403)
**BLAND, Jay,** Nondestructive testing of welds, 17: 11168 (TID-15756)
**BLEIBERG, M. L.,** Effects of burnup on oxide ceramic fuels, 17: 11270 (WAPD-T-1455)
**BLEIL, C. E.,** Energy transport in bombarded CdS, 17: 11290
**BLOCH, Tod,** Calibration of thyroid uptake systems, 17: 10343
**BLOCK, M.,** Irradiation of cerebral astrocytomata, 17: 10438
**BLOKH, G. A.,** Resistance to irradiation of silicate-filled rubber vulcanizates, 17: 11286
**BLOKHINTSEV, T. D.,** Hydrogen–D bubble chamber in magnetic field, 17: 10930
**BLOMEKE, J. O.,** Engineering of pot calcination process, 17: 12050 (TID-7646(p.69-82))
**BLOOM, H. J. G.,** Irradiation of cerebral astrocytomata, 17: 10438
**BLOSSER, T. V.,** Mobile radiation measurement laboratory, 17: 10877
**BLUM, J. R.,** Ergodic transformations, 17: 11068 (TID-15948)
**BLUM, R.,** Geomagnetic field and solar corpuscular radiation, 17: 11449
**BLUME, R. J.,** NMR saturation in Li, 17: 11392
**BOATMAN, J. C.,** Reactions of Nb(V) halides with pyridine, 17: 10500 (IS-385)
**BOCCHI, O.,** Action of bromoform and chloroform on pyrroles, 17: 10668 (NP-tr-941)
**BOCK, E.,** Cross sections for neutron inelastic scattering and (n,2n) processes, 17: 11587 (AE-88)
**BODINE, J. E.,** Reprocessing studies on irradiated UC reactor fuel, 17: 10736 (NAA-SR-7511)
**BOGOTT, Siegfried,** Segregation of Al–Zn and Al–Cu alloys, 17: 11246
**BOHNDORF, Werner,** Radiation effects on extremities of chickens, 17: 10471
**BOLDEMAN, J. W.,** Neutron temperature measurement using Lu, 17: 11586 (AAEC/TM-164)
**BOLLMANN, W.,** Prog. rpt. on radiation effects on pressure vessel steels, 7–9/62, 17: 11188 (EURAEC-485)
**BOLOGNA, G.,** Linear polarization of photons in multi-Bev region, 17: 10896 (LNF-62/107)
**BOLT, R. O.,** Prog. rpt. on radiation stability of organic fluids, 17: 11268 (TID-16999)
**BOLZE, Ernest M.,** Versatile bubble-chamber track measuring stage, 17: 11001 (BNL-6095)
**BOND, V. P.,** Effects of radiations on early responses in mammal, 17: 10358 (BNL-6575)
**BONI, A. L.,** Rapid determination of I-131 in milk, 17: 10554
**BONSE, Gustav,** Radiation effects on extremities of chickens, 17: 10471
**BOOZ, G.,** Cystamine protection of irradiated thymocytes, 17: 10487
**BOPP, Fritz,** Quantum mechanics of relativistic particles, 17: 11579
**BORCHERS, Heinz,** Piezoelectric pulses during stress of Al–3% Mg and Al, 17: 11250
**BOREN, Herbert O.,** Thermodynamic properties of Y and Fe pentacarbonyl, 17: 10580 (BM-RI-6155)
**BORGHESE, Elio,** Organ culture as technique for causal embryology, 17: 10407
**BORN, H.-J.,** Applicability of dibutyl ether for preparation of irradiated fuel by extraction, 17: 10755
**BOSE, S. K.,** Higher-order weak interactions, 17: 11522
**BOTTERELL, E. H.,** Localization of brain tumors, 17: 10278
**BOTTERO, M.,** Radiation effects on collagens. III., 17: 10465
**BOUSVAROS, George A.,** Coronary arteriography by single x-ray exposure, 17: 10267
**BOUTOT, P.,** Equipment decontamination at Marcoule, 17: 10761
**BOUZIGUES, H.,** Equipment decontamination at Marcoule, 17: 10761
**BOWDITCH, F. H.,** High-temperature heat transfer, 17: 10811
**BOWEN, I. Gerald,** Nuclear bomb effects computer, 17: 10845 (CEX-62.2)
**BOWIE, E. J. Walter,** Anemia of leukemia, 17: 10341
**BOWLES, K. L.,** Measuring plasma density of magnetosphere, 17: 11447
**BOWMAN, A. L.,** Superconductivity of $Ta_2C$, $Nb_2C$, and $V_2C$, 17: 11391
**BOWMAN, Robert L.,** Flow-through scintillation counting of C-14 and H-3, 17: 11027
**BOYD, R. G.,** Indirect relativistic effect on 5f electrons in U, 17: 11395
**BOYNE, C. D.,** Coincidence-count $\alpha$ particulate air monitor, 17: 10532 (HW-SA-2554)
**BOZEK, Eugeniusz,** Fast-slow coincidence circuit with time to pulse-height converter, 17: 11033
**BOZZINI, A.,** Chromosomic mutants in "Cappelli" wheat, 17: 10389
**BOZZINI, A.,** Morphological mutations in "Cappelli" wheat, 17: 10390
**BRADY, Edward L.,** Flat-plate solar thermoelectric conversion panels, 17: 11300 (ASD-TDR-62-214)
**BRANDAO, F. A. J. A.,** Extraction of U(IV) by phosphates and phosphonates, 17: 10745 (TID-15773)
**BRANDKAMP, W. W.,** Radiation effects on ovarian and cervical cancer cells, 17: 10261
**BRANDSHTETR, I.,** Separation of Fm and Md, 17: 10735 (JINR-P-1075)
**BRANDT, Reinhard,** Spontaneous fission of heavy isotopes, 17: 11649 (UCRL-10481)
**BRANDT, S. B.,** Propos of E. K. Gerling's remarks, 17: 10831
**BRANDUS, I.,** Collisions between spin-½ and spin-0 particles, 17: 11570
**BRAUER, P.,** Luminescent spectra of Tl salt solutions, 17: 10650
**BRAUN, H.,** Metallic Mo. II. Molybdenum alloys, 17: 11224
**BRAUN, J.,** Hand monitor for simultaneous measurement, 17: 10962
**BRAUN, J.,** Neutron streaming in $D_2O$ pipes, 17: 11588 (AE-98)
**BRAUN, M. P.,** Niobium and Zr effects on austenitic steel, 17: 11210
**BRAUN, W.,** Preparing labeled drugs by neutron activation, 17: 10683
**BRAUNSTEIN, J.,** Association constants of Cd and Cl ions in $NH_3$, 17: 10594 (TID-15741)
**BRAY, L. A.,** Solvent extraction of Cs by dipicrylamine, 17: 10731 (HW-SA-2620)
**BRAYER, R. C.,** Pneumatic vibratory compaction of $UO_2$, 17: 11145 (CEND-153(Vol.1)(p.45-59))
**BRECKENRIDGE, R. A.,** Blast-closure valve, 17: 10776 (NP-12454)
**BREIT, G.,** Nucleon-nucleon scattering theory, 17: 11568
**BREIT, G.,** Semiclassical treatment of quantum problems, 17: 11932
**BREIT, G.,** Vector mesons and nucleon-nucleon spin-orbit interaction, 17: 11491 (TID-15930)
**BREMER, A. B.,** Prog. rpt. on power reactor program, 11/62, 17: 11097 (NMI-7257)
**BREWER, Leo,** Thermodynamics of suboxide vaporization, 17: 10645
**BRIDENBAUGH, P. M.,** Fluorescent lifetime of Tb, 17: 10626
**BRIFFOD, G.,** Anomalous diffusion in a plasma, 17: 11857
**BRINK, G. O.,** Summation counter for detecting weak signals, 17: 10917

(UCRL-6832)
**BRITTIN, Wesley E.**, Second quantization in phase space, 17: 11927
**BROADBANK, R. W. C.**, Rapid assay of Ca in milk, 17: 10551
**BRODKEY, Robert S.**, Heat and momentum transfer in laminar flow, 17: 11842
**BROMLEY, D. A.**, Target polarization effects, 17: 11662
**BROOTHAERTS, J.**, Modification of U isotope in irradiation, 17: 11253 (BLG-140)
**BROSSET, Cyrill**, X-ray methods in chemical analysis, 17: 10947
**BROWN, D. J.**, Radiological monitoring of ground $H_2O$, 17: 10822 (HW-SA-2566)
**BROWN, D. P.**, Coincidence-count $\alpha$ particulate air monitor, 17: 10532 (HW-SA-2554)
**BROWN, D. P.**, Instrumentation, 17: 10852 (HW-73337(p.238-97))
**BROWN, G. E.**, Many-body problems, 17: 11481 (NP-12435(Pt.I))
**BROWN, G. E.**, Many-body problems, 17: 11482 (NP-12435(Pt.II))
**BROWN, J. E.**, Prog. rpt. on radiological research, 1-12/61, 17: 10847 (HW-73337)
**BROWN, K. B.**, Prog. rpt. on chemical technology, 1–3/62, 17: 10740 (ORNL-TM-181)
**BROWN, William F.**, Thermal efficiency of coated annular fins, 17: 10796 (IS-571)
**BRUBAKER, Wilson M.**, Ion pump, 17: 10944
**BRUBAKER, Wilson M.**, Quadrupole mass filter, 17: 10945
**BRUCE, David W.**, Toxicity of rare earth compounds, 17: 10484 (NP-12251(p.90-8))
**BRUCE, R. S.**, Precipitation of Sr-85 from urine, 17: 10276
**BRUCKER, George J.**, Capture of electrons into stable betatron orbits, 17: 11810 (USASRDL-TR-2257)
**BRUENGER, F. W.**, Metabolism of Pu-239 in adult beagles, 17: 10319
**BRUENGER, F. W.**, Plutonium extraction from biological material, 17: 10298 (COO-226(p.58-65))
**BRUNNER, G.**, Sizing of targets of x-ray sources, 17: 11353
**BRUNO, R.**, Ultrastructure of Purkinje cells in irradiated animals, 17: 10460
**BRUSH, Daniel S.**, Flat-plate solar thermoelectric conversion panels, 17: 11300 (ASD-TDR-62-214)
**BRUSH, S. G.**, Classical systems of charged particles, 17: 11497 (UCRL-6450-T(Rev.I))
**BRYAN, Jon**, Collector anodes in gas-flow G-M counter, 17: 11013 (UCRL-6845)
**BRYANT, Jay C.**, Radiation response in tissue culture, 17: 10429
**BRYNJOLFSSON, Ari**, Electron irradiation facility at Danish AEC, Risø, 17: 11812
**BUBEN, N. Ya.**, Plastification of polyethylene by radiolysis, 17: 10688
**BUCHHOLZ, E.**, Reaction $P^{31}(\gamma,n)P^{30}$, 17: 11653
**BUDBERG, P. B.**, Constitution diagram of Ti–Nb–Cr alloy, 17: 11212
**BUDKE, L.**, Protection of cells against ionizing radiation. I., 17: 10491
**BUDZANOWSKI, A.**, Elastic scattering angular distributions, 17: 11688
**BUMPUS, C. F., Jr.**, Void and pressure by fission track nucleation during power bursts, 17: 11952 (NAA-SR-7086)
**BUNDY, R. D.**, Heat transfer of ethylene glycol, 17: 10808
**BURBACH, Werner**, Lead shieldings for radioactive substances, 17: 11904
**BURDICK, E. E.**, Performance of black vs. gray control rods, 17: 12029
**BURDITT, R. B.**, Salt bath heat transfer rates for U, 17: 10805 (Y-1410)
**BURKE, D. G.**, Decay of Pm-151, 17: 11652
**BURKE, Philip G.**, Collisions of electrons and positrons with atomic H, 17: 11390
**BURNETTE, R. D.**, Carbon transport and corrosion in GCR, 17: 11981 (GA-2630)
**BURROUS, M. L.**, Prog. rpt. on radiation stability of organic fluids, 17: 11268 (TID-16999)
**BURROW, Gerald N.**, BEI values of adolescents exposed to Nagasaki bomb, 17: 10371
**BURSHTEIN (BURSTEIN), E. L.**, Control system for beam in synchrotron, 17: 11764 (BNL-767(p.48-63))
**BURSHTEIN, E. L.**, Cyclic accelerators for high energies, 17: 11769 (BNL-767(p.91-9))
**BURSON, S. B.**, Computer program for analysis of complex $\beta$ spectra, 17: 11443
**BURTON, Milton**, Radiolysis of liquid methanol, 17: 10699
**BUSCHBECK, F.**, Electromagnetic isotope separator of SGAE, 17: 10923



**BUSSE, W.**, Handling devices in $\gamma$ radioscopy, 17: 10818
**BUSTAD, L. K.**, Transfer of transuranic elements to milk, 17: 10326
**BUSTER, D. S.**, Metabolism of Pu-239 in adult beagles, 17: 10319
**BUTLER, M. J.**, Apparatus for checking radiation leakage from diagnostic x-ray tubes, 17: 11018
**BUTT, D. K.**, Electron-$\gamma$ angular correlation with radiations from de-excitation of Pt-192, 17: 11666
**BUTT, E. P.**, Pulsed toroidal gas discharge apparatus, 17: 10982
**BUTTS, Joseph S.**, Treatment of mosquito larvae with P-32, 17: 10423

## C

**CAHILL, John P.**, Transmission of thermal radiation from nuclear detonations, 17: 11298 (AFCRL-62-456)
**CALAME, Gerald P.**, Treatment of asymmetric thin regions, 17: 11596 (TID-15752)
**CALEF, E.**, Genetic experiments in Borek-Ryan effect, 17: 10382
**CALESNICK, Benjamin**, Absorption and excretion of Hg-203 mercaptomerin Na, 17: 10345
**CAMERON, A. E.**, Determination of atomic weights by mass spectrometry, 17: 10614
**CAMERON, A. G. W.**, Origin of atmospheric Xe, 17: 11445 (NASA-TN-D-1685)
**CAMP, D. C.**, Shape of $0^+ \rightarrow 0^+$ positron spectrum in Ga-66, 17: 11724
**CAMPOS, F. P.**, Neutron and x-ray diffraction studies of non-stoichiometric metal hydrides, 17: 10578 (ANL-FGF-332)
**CANEL, E.**, Quasi-particle approach to many-body problem, 17: 11581
**CAPELLEN, Jennings**, Hydrolysis of rare-earth carbides, 17: 10591 (IS-499)
**CARBONNIER, R.**, Production of $D_2O$ by electrolysis, 17: 11056 (CEA-tr-A-1159)
**CARDONA, Manuel**, Resonances of plasma sphere in magnetic field, 17: 11858
**CARFAGNA, M.**, Variations of fitness factors in irradiated Drosophila, 17: 10384
**CARLSON, R. D.**, Uranium dioxide–NaK slurry as reactor fuel, 17: 11077 (ANL-6644)
**CARNELL, P. J. H.**, Preparation and properties of $MoBr_4$, 17: 10590 (IS-487)
**CARP, Richard I.**, Plaquing efficiency at 40°C in $D_2O$, 17: 10290
**CARR, Duane T.**, Carbon-13 splittings in fluorine NMR spectra, 17: 11356
**CARREA, Antonio J.**, Production of thin plates of $UO_2$, 17: 11167 (NP-12228)
**CARROLL, E. E.**, Extrapolation lengths in pulsed water systems, 17: 11600 (WAPD-T-1490)
**CARROLL, J. G.**, Prog. rpt. on radiation stability of organic fluids, 17: 11268 (TID-16999)
**CARTER, E. B.**, Thresholds observed in $(\alpha,n)$ and $(p,n)$ reactions, 17: 11715
**CARTER, H. G.**, Energy storage mechanism in liquid hydrogen, 17: 11262 (NARF-62-15T)
**CARTER, L. A.**, Emergency planning for radiation accident, 17: 10855 (HW-SA-2609)
**CASEY, H. W.**, Transfer of transuranic elements to milk, 17: 10326
**CASKEY, G. R., Jr.**, Failures of $UO_2$ fuel tubes, 17: 11157 (CEND-153 (Vol.II)(p.77-99))
**CASSAGNOU, Y.**, Ericson fluctuations in $Al^{27}(d,\alpha)Mg^{25}$, 17: 11675
**CASTANERA, T. J.**, Tumors of pancreas in irradiated and nonirradiated rat, 17: 10432
**CASTELLI, Carlo A.**, Lymph of thoracic duct in irradiated rabbits, 17: 10462
**CATER, E. David**, Vaporization and thermodynamic properties of US and UOS, 17: 10598 (TID-15796)
**CATRON, H. C.**, Lithium-6 and $Li^7(n,2n)$ cross sections, 17: 11722
**CATSCH, A.**, Therapeutic removal of internally deposited radionuclides, 17: 10333
**CATTANEO, R.**, Bone metabolism of Sr-85 and Sr-89, 17: 10348
**CAVALIERI, Ralph R.**, Iodine-132 in study of thyroid function, 17: 10342
**CHACHATY, Claude**, Spectra of solid irradiated formaldehyde, 17: 10695
**CHAMBERS, Ll. G.**, Space time in Hund gravitational theory, 17: 11351
**CHAMBRON, William**, Electron irradiation of Fe–Ni alloy, 17: 11274
**CHANDRASEKHAR, B. S.**, High-field superconducting solenoids, 17: 11349

**CHANG, Yen,** High voltage supply for scintillation counters, 17: 11022
**CHAO, B. T.,** Prog. rpt. on bubble motion in turbulent liquid stream, 9-12/62, 17: 10803 (TID-17719)
**CHAPIRO, Adolphe,** Polymerization of bis(chloromethyl)-3,3-oxetane, 17: 10694
**CHAPLIN, G. B. B.,** Semiconductors in nuclear instrumentation, 17: 10957
**CHAPPELL, Willard R.,** Second quantization in phase space, 17: 11927
**CHARAP, John M.,** Complex angular momentum in many-channel potential-scattering problems. II., 17: 11501 (UCRL-10209)
**CHARAP, John M.,** Theory of nucleon-nucleon scattering in strip approximation, 17: 11498 (UCRL-10028)
**CHARLESBY, A.,** Radiation protection in aqueous polymer solutions, 17: 10690
**CHASE, Herman B.,** Prog. rpt. on cosmic ray and microbeam effects on skin, 1-12/62, 17: 10363 (TID-17676)
**CHATELAIN, Jack E.,** Limit of quantum theory of radiation damping, 17: 11916
**CHATTERJEE, S.,** Cysteamine protection of x-ray-induced aberrations, 17: 10492
**CHAUDHURI, J. P.,** Cysteamine protection of x-ray-induced aberrations, 17: 10492
**CHAUDRON, G.,** Prog. rpt. on corrosion of stainless steels, 7-10/62, 17: 11115 (EURAEC-482)
**CHEKHOVSKOI, V. Y.,** Tungsten enthalpy from 350° to 2000°C, 17: 11207
**CHEN, Catherine S. Hsia,** Polymerization of acenaphthylene induced by radiation, 17: 11283
**CHEN, J. C.,** Boiling K heat transfer project loop design, 17: 10791 (BNL-6142)
**CHEN, Katherine Lee,** Nuclear reactions in Sc-45 and Ti-47, 17: 11624 (NYO-10386)
**CHENG, Hua-sheng,** Separation of Pr-144 from Ce oxide, 17: 10762
**CHERNOCK, W. P.,** Economics of powder packed fuel elements, 17: 11142 (CEND-153(Vol.1)(p.3-10))
**CHERNOPLEKOV, N. A.,** Delay system for neutron time-of-flight spectroscopy, 17: 11036
**CHERNOPLEKOV, N. A.,** Studying condensed substance dynamics by neutron scattering, 17: 12032
**CHERNOV, P. V.,** Millimeter radiospectroscope, 17: 10931
**CHESLOW, M. D.,** Prog. rpt. on radiation-resistant solar cell, 12/62, 17: 10777 (NP-12474)
**CHEVALIER, G.,** Iodine-131 stopping, 17: 10844 (CEA-Bib-29)
**CHICK, Helen J.,** Loss of plasma through magnetic aperture of traps, 17: 11841 (AEC-tr-5620)
**CHIDLEY, B. G.,** Lattice parameters for NPD and CANDU fuel elements in $D_2O$, 17: 11939 (CRL-75)
**CH'IEN, Chi-p'eng,** High voltage supply for scintillation counters, 17: 11022
**CHIKILDINA, L. D.,** Uranium salts in nuclear emulsions, 17: 11039
**CHILOK, A.,** Solution of kinetic equations, 17: 11308 (JINR-P-1113)
**CHILTON, A. B.,** Differential dose albedo for $\gamma$ rays on concrete, 17: 11901 (NP-12455)
**CHING, Te May,** Radiation effects on wheat, 17: 10374
**CHIOU, C.,** Alloy concentration for ideal superconductivity transitions, 17: 11376
**CHIU, L. Y. Chow,** Hfs of metastable state of Kr-83, 17: 11692
**CHIZHOV, O. S.,** Mass-spectroscopic study of carbohydrates, 17: 10557
**CHMUTOV, K. V.,** Radiation stability of ion exchanger resins, 17: 10719
**CHOUDHURY, D. C.,** Effects of configuration mixing on the $3^-$ state of Pb-298, 17: 11720
**CHOUROULINKOV, I.,** Appearance of lymphoid tumors in mice, 17: 10406
**CHOW, P. C.,** System to obtain higher space resolution in nuclear emulsions, 17: 11333 (TID-17640)
**CHRISTELL, Roland,** Determination of As by activation analysis, 17: 10542
**CHRISTENSEN, Hans,** Isomorphic substitutions of Ca by Sr in Ca hydroxyapatite, 17: 10576 (AE-96)
**CHRISTENSEN, W. R.,** Gingival ulceration induced in beagles, 17: 10296 (COO-226(p.35-49))
**CHRISTENSEN, W. R.,** Radium studies in man soon after injection, 17: 10300 (COO-226(p.71-77))
**CHRISTENSEN, W. R.,** Skeletal toxicity of Pu-239 in beagles, 17: 10320
**CHRISTENSON, C. W.,** Ceramic sponge process, 17: 12052 (TID-7646 (p.94-101))
**CHRISTIAN, John E.,** Radioisotopic method of evaluating dispersed systems. I., 17: 10884
**CHRISTMAN, R. P.,** Criticality predictions of PWR-2 design, 17: 11994 (WAPD-T-1370)
**CHRISTMAN, R. P.,** Power distribution in PWR-2 mockup, 17: 11993 (WAPD-T-1369(Rev.))
**CHU, E. L.,** Design of magnetic momentum slits, 17: 11796 (SLAC-6)
**CHUDARS, Ya.,** Determination of moisture in peat by neutron method, 17: 10559
**CHUMAKOV, N. I.,** Ion beam energy spread, 17: 11780 (BNL-767(p.288-92))
**CHURCH, E. L.,** Penetration effects in magnetic-dipole L-shell internal conversion, 17: 11618 (BNL-6647)
**CIBOROWSKI, Janusz,** Effect of electrostatic phenomena on fluidization process, 17: 11202 (AEC-tr-5621)
**CINDRO, N.,** Interaction of deuterons with nuclei, 17: 11676
**CINELLI, G.,** Theory of a coaxial shunt, 17: 11334 (TID-17677)
**CLAIBORNE, Lewis T.,** Superconducting Nb-Zr alloys, 17: 11400
**CLARE, J. W. H.,** Composition of X phase in Al-Mn-Ni, 17: 11249
**CLARK, James S.,** Prog. rpt. on Nb alloy extrusion, 10/15/62-1/15/63, 17: 11140 (AMC-TR-7-775(VII))
**CLARK, W. I.,** X-ray diffraction of irradiated fuel, 17: 10894 (HW-SA-2616)
**CLARKE, Constance M.,** Graft-vs.-graft immunological tolerance in radiation chimeras, 17: 10270
**CLARKE, H. G., Jr.,** Shipping containers for radioactive materials. I., 17: 10780 (NYO-9859)
**CLARKE, William D.,** Oceanographic literature of Santa Barbara channel area, 17: 10826 (TID-17722)
**CLAUSER, Francis H.,** Concept of field modes and behavior of MHD field, 17: 11365
**CLAYTON, E. D.,** Critical mass experiments with $Pu(NO_3)_4$, 17: 11459 (HW-SA-2432(Rev.))
**CLAYTON, Glen T.,** Structure of liquid Hg, 17: 11232
**CLUSIUS, Klaus,** Concentration distribution of isotopic mixtures, 17: 11059
**COBB, J. K.,** Shower development and heating in waveguide structure with 800-Mev electron beam, 17: 11794 (SLAC-3)
**COCHRAN, Terence H.,** Liver injury in beagles with Pu-239, 17: 10328
**CODY, W. J.,** Positron elastic scattering by atomic H, 17: 11328 (TID-15769)
**COHEN, Paul,** Inorganic ion-exchange resins, 17: 10710
**COHEN, Saul G.,** Prog. rpt. on radiation-induced reactions, 11/61-11/62, 17: 10680 (TID-17584)
**COHN, C. E.,** Computer study of noise measurement errors, 17: 10916 (TID-17788)
**COHN, C. E.,** Control rod calibrations for Juggernaut, 17: 11964 (TID-17815)
**COHN, S. H.,** Kinetics of Ca-47 and Sr-85 in man, 17: 10293 (BNL-6108)
**COLE, Alan Rex,** Sputtering by incident positive ions, 17: 11318 (NP-12357)
**COLE, G. H. A.,** Scattering of neutrons by square-mound-potential gas, 17: 11607
**COLE, G. R.,** Failures of $UO_2$ fuel tubes, 17: 11157 (CEND-153(Vol.II) (p.77-99))
**COLE, Leonard J.,** Post-irradiation glomerulosclerosis, 17: 10433
**COLEGROVE, F. D.,** Large He-3 nuclear polarization, 17: 11730
**COLES, H. J.,** Mitchell's SCLMR, marine reactor, 17: 12006
**COLLEY, D.,** Comparison of $\eta$, $\tau$, and $\tau'$ decays, 17: 11553
**COLLINS, Kenneth E.,** Thermal annealing of recoil Br-82, 17: 10673 (BNL-6535)
**COLOMBO, G.,** X-ray effects on guinea pig cells, 17: 10383
**COLVIN, Curtis A.,** Spectrophotometric determination of Np, 17: 10533 (HW-SA-2657)
**COLVIN, R. V.,** Electric resistivity due to electron-phonon scattering in Y and Lu, 17: 11221
**COMANESCU, V.,** Electrode for (n,n) and (n,$\gamma$) radioactive logging, 17: 10836
**COMAR, C. L.,** Prog. rpt. on fission product metabolism, 4/62-1/63, 17: 10310 (TID-17789)
**CONDON, Paul E.,** Angular distribution of $K_{e3}$ decay products, 17: 11484 (NP-12460)
**CONDON, Richard A.,** Void fractions in parallel rod arrays, 17: 10812
**COHEN, P. E.,** Chromosome damage after diagnostic x irradiation,

17: 10435
**CONGDON, C. C.,** Modification of radiation injury by leukemoid leukocytes, 17: 10283
**CONNELL, R. A.,** Alloy concentration for ideal superconductivity transitions, 17: 11376
**CONRAD, F. J.,** Determination of Cr, Co, Fe, and Ni in alloys, 17: 10539 (TID-16296)
**CONTIN, M.,** X-ray-induced somatic mutations in maize seedlings, 17: 10394
**COOK, G. B.,** Industrial isotope applications, 17: 10977
**COOPER, George W.,** Hematopoietic studies in x-irradiated newborn rats, 17: 10368
**COOPER, P. F., Jr.,** Slightly inelastic p-d scattering, 17: 11540
**CORADOSSI, N.,** Beryllium determination in granite diorites, 17: 10827
**CORAZZA, G.,** "AdA" accumulator ring for electrons and positrons, 17: 11820
**CORBETT, John D.,** Solutions of Ga(I) salts in aqueous base, 17: 10589 (IS-481)
**CORENZWIT, E.,** Intermediate isotope effect of Mo and $Mo_2Ir$, 17: 11375
**COREY, K. R.,** Detection of bone metastases, 17: 10344
**CORREY, Thomas B.,** Rate of etching and roughness of cathodically etched metal surfaces, 17: 11089 (HW-SA-2559)
**CORUM, J. M.,** Buckling of initially out-of-round tubes subjected to external pressure, 17: 11192 (ORNL-3299)
**COSGROVE, G. E.,** Modification of foreign spleen reaction, 17: 10434
**COTTIER, H.,** Leukemogenic effect of whole-body $\gamma$ irradiation, 17: 10354 (BNL-6105)
**COULON, E. M.,** Effects of $\gamma$ radiation on mouse testis, 17: 10361 (TID-15852)
**COURANT, E. D.,** Acceleration of deuterons or $\alpha$ particles in AGS, 17: 11784 (BNL-6673)
**COVEY, P. A.,** Compensating for temperature dependence of monitoring system, 17: 11014 (USNRDL-TR-604)
**COWHERD, Chatton, Jr.,** Interfacial reactions with reference to metal corrosion, 17: 10601 (TID-15942)
**COX, D. F.,** Effect of paternal irradiation on swine, 17: 10414
**COXON, T.,** Reactor control, 17: 10983
**CRAIG, Iris L.,** X-ray-induced mutation in *Medicago sativa L.*, 17: 10396
**CRAIG, Iris L.,** X-ray-induced single-leaf mutation in *Medicago sativa L.*, 17: 10399
**CRAIG, P. P.,** Binding of isolated Fe impurity atoms, 17: 11230
**CRAIG, R. D.,** Analysis of solids by mass spectrometry, 17: 10943
**CRANE, M.,** Wet steam as reactor coolant, 17: 11965 (UNC-5008-I)
**CRAWFORD, C. K.,** Measuring electron-ionization cross sections, 17: 11319 (NP-12358)
**CRAWFORD, Frank S., Jr.,** Determination of branching ratio $\Gamma(\eta \to \pi^+\pi^-\gamma)/\Gamma(\eta \to \pi^+\pi^-\pi^0)$, 17: 11552
**CRENSHAW, C. L.,** Corrosion rate of preoxidized Zy-2, 17: 11132 (KAPL-M-AA-4)
**CRIBIER, D.,** Application of inelastic neutron scattering, 17: 11222
**CRISTY, G. A.,** Reduced pressure backflow preventer, 17: 10515 (ORNL-3380)
**CROMROY, H. L.,** X-ray sensitivity of *E. coli*, 17: 10426
**CRONKITE, E. P.,** Bone marrow cell transfusions, 17: 10292 (BNL-6106)
**CRONKITE, E. P.,** Leukemogenic effect of whole-body $\gamma$ irradiation, 17: 10354 (BNL-6105)
**CROPSEY, M. G.,** Radiation effects on wheat, 17: 10374
**CROUTHAMEL, C. E.,** Helium-purification for inert-atmosphere boxes, 17: 10772 (ANL-6652)
**CUBICCIOTTI, Daniel,** Thermodynamics of liquid solutions of Bi and S, 17: 10629
**CUNNINGHAM, George W.,** High-temperature irradiation test of $UO_2$ fuels, 17: 11254 (BMI-1608)
**CUPERMAN, S.,** Radiation losses from hot spherical plasma, 17: 11855
**CURTIS, Elizabeth J.,** Association between maternal radiation and mongolism, 17: 10436
**CURTIS, H. J.,** Biological effects of heavy cosmic particles, 17: 10353 (BNL-6098)
**CURTIS, W. K.,** Development of master-slave manipulator, 17: 10787
**CUTKOSKY, R. E.,** Analytic properties of S matrix in perturbation theory, 17: 11483 (NP-12436)
**CUVELIER, C.,** X-ray effects on bilirubin and biliverdin, 17: 10376
**CZAKOW, Julian,** Spectral analysis of powders and solutions, 17: 10952
**CZAPSKI, G.,** Oxidation of $H_2O_2$ by Ce(IV), 17: 10631
**CZARNODOLA, Helena,** Effects of radiation on aliphatic polyethers, 17: 10678 (PAN-306/XVII)
**CZERNIAK, P.,** Turnover rate of Zn determined by Zn-65, 17: 10275
**CZERNIEJEWSKI, F. R.,** Eigenvalue matrix solution to N-component neutron interaction problems, 17: 11458 (HW-75887)
**CZUBEK, Jan A.,** Neutron-neutron well logging theory. I., 17: 10833
**CZYZEWSKI, O.,** Interactions of $\pi^-$ mesons with Xe, 17: 11673

# D

**DAANE, A. H.,** Electric resistivity of rare-earth alloys, 17: 11190 (IS-477)
**DAANE, A. H.,** Electron requirements on bonds in metal borides, 17: 11306 (IS-473)
**DACHILLE, Frank,** Solid-phase reactions at high pressures, 17: 10503 (NP-12359)
**DAHLER, John S.,** Angular momentum transport in quantum statistical mechanics, 17: 11917
**DAITCH, P. B.,** Transients in pulsed moderators, 17: 11597 (TID-16085)
**DAKIN, V. I.,** Radiolysis and radiation-induced oxidation of diisopropyl ether, 17: 10705
**DALAPALME, A.,** Uranates of Co and Mn, 17: 10633
**DALY, James C.,** Environmental levels of Ra, 17: 10529 (ANL-6637(p.59-84))
**D'AMATO, F.,** Embryonic transplant as research medium, 17: 10386
**D'AMATO, F.,** Morphological mutations in "Cappelli" wheat, 17: 10390
**DAMBURG, R. Ya.,** Strong bond and exchange in collisions of electrons with H atoms, 17: 11361
**DANCY, Edna A.,** Free energy of formation of Ce and Pr monocarbides, 17: 10644
**DANDL, R. A.,** Neutron production from D plasma, 17: 11866
**D'ANGELO, N.,** Excitation of electrostatic plasma near ion cyclotron frequency, 17: 11851
**DANIEL, J. L.,** Thermal conductivity of $UO_2$, 17: 11258 (HW-69945)
**DARBY, J. B., Jr.,** Binary systems of Tc-99 with transition elements, 17: 11220
**DARBY, J. B., Jr.,** Solution of transition elements in liquid Al, 17: 10577 (ANL-FGF-292)
**DARBY, J. B., Jr.,** Superconducting phases in Mo–Tc, 17: 11363
**DARYALOVA, S. L.,** Distribution of radioactive Y salts in animals, 17: 10443
**DASGUPTA, Padmanabha,** Resonant partial wave amplitude, 17: 11530
**DAUTREPPE, Daniel,** Electron irradiation of Fe–Ni alloy, 17: 11274
**DAVIDSON, D. F.,** Wigner energy measurements, 17: 10974
**DAVIDSON, E.,** X-ray instrumentation, 17: 10948
**DAVIES, D. M.,** Prog. rpt. on power reactors, 10/62, 17: 11096 (NMI-7256)
**DAVIES, D. M.,** Prog. rpt. on power reactor program, 11/62, 17: 11097 (NMI-7257)
**DAVIS, Donald H.,** Critical-size calculations for neutron systems, 17: 11462 (UCRL-6707)
**DAVIS, M. W., Jr.,** Calcination of radioactive wastes in molten S, 17: 12046 (TID-7646(p.20-36))
**DAVIS, M. W., Jr.,** Theoretical investigation of agitated ion exchange beds, 17: 10763
**DAVIS, R. H.,** Thresholds observed in (α,n) and (p,n) reactions, 17: 11715
**DAVIS, Raymond, Jr.,** Cosmic ray produced Ar-37 and Ar-39 in meteorites, 17: 11448 (BNL-6545)
**DAVIS, Richard Lee,** High-voltage pulse resistors, 17: 10905 (SCTM-230-62(14))
**DAWSON, K. B.,** Excitation of x-irradiated isolated frog nerve, 17: 10417
**DAYTON, R. W.,** Reactor Materials, Vol. 5, No. 3, 1962, 17: 11123
**DAYTON, R. W.,** Reactor Materials, Vol. 5, No. 4, 1962, 17: 11124
**DEAN, John A.,** Tri-n-butylphosphine sulfide as organic extractant, 17: 10754
**DEAN, O. C.,** Preparation of oxide fuels for vibratory compaction, 17: 11144 (CEND-153(Vol.1)(p.23-38))
**DEBERTIN, K.,** Detection of particles associated with d-d gas target, 17: 11467 (IKF-4)
**DE BORNIER, Bernard Magnan,** Protection by cysteine of phosphatase, 17: 10405

**DE CAPOA, A.**, Variations of fitness factors in irradiated Drosophila, 17: 10384
**DEEM, H. W.**, Thermal conductivity of $UO_2$, 17: 11258 (HW-69945)
**DE FEO, P.**, Trapped-flux in a superconducting ring, 17: 11291
**DE GANAHL, C. F.**, Supercritical water reactor shield, 17: 11988 (PWAC-100)
**DE GENNES, P. G.**, NMR modes in magnetic material. I., 17: 11379
**DE HALAS, D. R.**, Evolution of $UO_2$ structure during irradiation of fuel rods, 17: 11260 (HW-SA-2650)
**DE HART, R. L.**, Modification of foreign spleen reaction, 17: 10434
**DE HOLLANDER, W. R.**, Particle size in packing of $UO_2$, 17: 11147 (CEND-153(Vol.1)(p.75-83))
**DE JUREN, J. A.**, Extrapolation lengths in pulsed water systems, 17: 11600 (WAPD-T-1490)
**DEKHTYAR, I. Ya.**, Position-electron annihilation in alloys, 17: 11275
**DE LA RIPELLE, Michel Fobre**, Excitation of giant photonuclear resonance, 17: 11734
**DELBECQ, Charles J.**, M-center formation in KCl, 17: 10653
**DELLA ROSA, R. J.**, Interlaboratory and interstandard comparisons of Sr-90, 17: 10299 (COO-226(p.66-70))
**DELOFF, Andrzej**, Threshold anomalies in inelastic collisions, 17: 11554
**DELORME, E. J.**, Recovery from lethal irradiation in rats, 17: 10437
**DEMCHENKO, N. P.**, Scintillation properties of 1,3-oxazole derivatives in polystyrene, 17: 11227
**DE MEVERGNIES, M. Neve**, Characteristics of neutron beams from BR2, 17: 12022 (BLG-147)
**DEMIDOV, V. P.**, Magnetic sound in plasma with thermal motion. I., 17: 11878
**DE MIER, W. V.**, Fission product and waste packaging, 17: 12040 (HW-74712)
**DEMIRKHANOV, R. A.**, Ion sources with plasma contraction by inhomogeneous field, 17: 11777 (BNL-767(p.224-53))
**DEMIRKHANOV, R. A.**, Penetration of magnetic field into plasma, 17: 11885
**DEMMITT, Thomas F.**, pH control by ion exchange in high pH systems, 17: 10499 (HW-SA-2595)
**DEMOS, P. T.**, Polarization of neutrons from photodisintegration of D, 17: 11551
**DEMPSEY, E.**, Cohesive and surface energies of Th and U dioxides, 17: 11217
**DE NIE, W.**, Determination of U isotopes by emission spectroscopy, 17: 10971
**DENISOV, S. P.**, Gamma recording by bremsstrahlung beam, 17: 11555
**DENNSTEDT, M.**, Conversion of pyrrole to pyridine, 17: 10669 (NP-tr-942)
de Oca, Hector Montes
*see Montes de Oca, Hector*
**DE PINHO, Alceu**, Electromagnetic transitions in deformed odd-odd nuclei, 17: 11654
**DE POORTER, Gerald Leroy**, Energy exchange between cold gas and hot tungsten surface, 17: 10609 (UCRL-10504)
**DERRIEN, Herve**, Resonant interaction of neutrons with U-238, 17: 11655
**DESAI, Bipin R.**, Angular momentum poles of S matrix for spin 1/2 particles, 17: 11913
**DESAI, Bipin R.**, S matrix in terms of its angular momentum poles, 17: 11914
**DE SANTIS, V. J.**, Prog. rpt. on refractories, 10–12/62, 17: 11191 (NP-12483)
**DE STEESE, John G.**, Thermionic emission of Re, 17: 11346
**DETWEILER, Robert Milan**, Displacement of Se atom in single-crystal ZnSe, 17: 11320 (NP-12360)
**DEVELL, Lennart**, Self-diffusion of $H_2O$, 17: 10613
**DE WAARD, H.**, E2/M1 mixing ratio of 123-kev transition in Fe-57, 17: 11701
**DE WETTE, F. W.**, Lattice defects in solid alpha He-3, 17: 11382
**DE WITT, H. E.**, Classical systems of charged particles, 17: 11497 (UCRL-6450-T(Rev.I))
**DIAMBRINI, G.**, Linear polarization of photons in multi-Bev region, 17: 10896 (LNF-62/107)
**DIAMOND, Herbert**, Alpha half lives of Po-216, At-217, and Rn-218, 17: 11632 (TID-16202)
**DIAMOND, Richard M.**, Extraction of acids by basic organic solvents. I., 17: 10750 (UCRL-10063)
**DIDORA, N. F.**, Precipitation of certain elements from fused $NH_4NO_3$, 17: 10621
**DIEBOLD, James Warren**, Radiation effects on solar cells, 17: 11263 (NP-12361)
**DIETRICH, M.**, Clearance of Fe-59 from plasma after total-body irradiation, 17: 10413
**DIETZ, Klaus**, Effect of $\pi$-$\pi$ interaction on $\pi$-N scattering, 17: 11578
**DIETZ, Leonard A.**, Measurement of two ion currents by pulse counting in mass spectrometer, 17: 10908 (TID-15865)
**DIETZ, Roland**, Spermatocyte division in tuplidae. III., 17: 10402
**DIETZ, Werner**, Importance of hole size for sieve irradiation, 17: 10497
**DI GIUGNO, G.**, "AdA" accumulator ring for electrons and positrons, 17: 11820
**DIKII, G. P.**, Automodel problems of magnetohydrodynamics, 17: 11438
**DIKII, G. P.**, Magnetohydrodynamics with axial symmetry, 17: 11439
**DILLEY, J.**, Radioprotective effects of cyanide and nitriles, 17: 10482 (NP-12251(p.47-66))
**DILLINGER, P.**, Radiolysis and radiation-induced oxidation of diisopropyl ether, 17: 10705
**DI PASQUALE, A.**, "Brown spot" character in Drosophila and x-ray response, 17: 10379
**DIRAC, P. A. M.**, Conditions for quantum field theory to be relativistic, 17: 11926
**DISSING-SOERENSEN, E.**, Electronic galvanometer, 17: 10958
**DISSING-SOERENSEN, E.**, Transistorized counting-rate meter, 17: 10959
**DITTMAR, Bruce**, Deuterium exchange of aryl 2-octyl sulfones, 17: 10670
**DOERING, Robert F.**, Milking systems for radioisotope separation, 17: 11050 (BNL-6697)
**DOJNIKOV, N. I.**, Two-stage 300-Bev proton circular accelerator, 17: 11768 (BNL-767(p.84-90))
**DON, Conway**, Coronary arteriography by single x-ray exposure, 17: 10267
**DONATO, L.**, Periodic integrator, 17: 11024
**DONETS, E. D.**, Transfer reactions in Th irradiation by Ne-22, 17: 11473 (JINR-P-1071)
**DONN, William L.**, Air waves from nuclear explosions, 17: 10837
**DONNE, M. Dalle**, High-temperature heat transfer, 17: 10811
**DORN, John E.**, Dislocation concepts of strain rate effects, 17: 11198 (UCRL-10498)
**DORN, John E.**, Plastic behavior of polycrystalline aggregates, 17: 11196 (UCRL-10152)
**DORSEY, J. H.**, Spectral analysis of GCRE and ML-1 reactor, 17: 11978 (AGN-TM-399)
**DOUGHERTY, Jean H.**, Effects of Ra-226 injections on peripheral blood values of beagle, .17: 10297 (COO-226(p.50-6))
**DOUGHERTY, Thomas F.**, Prog. rpt. on radiobiology research, 9/30/62, 17: 10294 (COO-226)
**DOULL, J.**, Blood vessels of irradiated rats, 17: 10485 (NP-12251(p.99-113))
**DOULL, J.**, Influence of chemical agents on radiation lethality, 17: 10481 (NP-12251(p.34-46))
**DOULL, J.**, Radioprotective effects of cyanide and nitriles, 17: 10482 (NP-12251(p.47-66))
**DOULL, J.**, Radioprotective effects of p-aminopropiophenone, 17: 10483 (NP-12251(p.67-89))
**DOVE, R. C.**, Construction and evaluation of 3-dimensional strain rosette, 17: 10783 (TID-17773)
**DOW, Norris F.**, Primary proton protection, 17: 11898 (N62-10900(Pt.III))
**DOW, Norris F.**, Primary proton protection, 17: 11899 (N62-10900(Pt.IV))
**DOWNEY, J. W.**, Binary systems of Tc-99 with transition elements, 17: 11220
**DOWNHAM, Tom**, Evaluation of radioactive decay data, 17: 10547
**DRACASS, J.**, Glass scintillators, 17: 10965
**DRAGANIC, Ivan**, Oxalic acid in chemical dosimeter, 17: 11030
**DRESNER, Lawrence**, Theory and technology of chain reactors, 17: 11975
**DRESSLER, R. T.**, Shippingport data acquisition system, 17: 10920 (WAPD-T-1447)
**DREYER, L.**, Prog. rpt. on high-density plasmas, 9/15–12/15/61, 17: 11826 (AD-273961)
**DRIGGERS, Frank E.**, Effects of neutron rethermalization in $D_2O$ coolants, 17: 11962 (TID-17574)
**DRIVER, G. E.**, Device for recording fuel element dimensions, 17: 10893 (HW-75746)

**DROBINSKI, J. C., Jr.,** Prog. rpt. on detection of radiation in static and flowing liquid H, 7-9/61, 17: 10900 (NI -12363)
**DRUMMOND, W. E.,** Cyclotron radiation from hot plasma, 17: 11849
**DUBECK, L.,** Thermal conductivity of superconductors, 17: 11406
**DU BOIS, Kenneth P.,** Radiation effects on thiophosphate-oxidizing enzyme system, 17: 10478 (NP-12251(p.1-11))
**DU BOIS, Kenneth P.,** Radiation effects on pyridine nucleotide-linked dehydrogenase activity, 17: 10479 (NP-12251(p.12-21))
**DU BOIS, Kenneth P.,** Toxicity of rare earth compounds, 17: 10484 (NP-12251(p.90-8))
**DUBOIS, Regis,** Radiation sterilization of chick embryo, 17: 10375
**DU BRIDGE, R. A.,** Thermocouple type detector for in-core power monitoring, 17: 10940
**DUCA, A.,** Condensation of Na molybdate, 17: 10611 (UCRL-Trans-894(L))
**DUCOTE, L. W.,** Summation counter for detecting weak signals, 17: 10917 (UCRL-6832)
**DUDELZAK, Boris,** Elastic electron-proton scattering, 17: 11506
**DUNCAN, James M.,** Hazards rpt. for Northrop reactor, 17: 12025 (NP-12299)
**DUNCOMBE, E.,** Acidity meter for uranyl nitrate solutions, 17: 10972
**DUNCOMBE, E.,** Wigner energy measurements, 17: 10974
**DUNLAP, Louise B.,** Controlled-potential coulometric titration of U(IV) and U(VI), 17: 10545
**DUPLAN, J. F.,** Mouse embryo factors in post-irradiation restoration, 17: 10421
**DUQUESNE, Maurice,** Internal conversion and *L* fluorescence in Pu-234, 17: 11657
**DURBIN, Patricia W.,** Distribution of transuranic elements in mammals, 17: 10324
**DURFEE, Robert L.,** Prog. rpt. on boiling heat transfer, 9/60-2/62, 17: 10801 (NYO-10345)
**DURIO, John,** Ring counter, 17: 11020
**DUTTA, B. C.,** Electron-γ angular correlation with radiations from de-excitation of Pt-192, 17: 11666
**DVORAK, V.,** Mossbauer effect and ferroelectric properties of ionic crystals, 17: 10639
**DZHAGATSPANYAN, R. V.,** Chlorination of Si-containing monomers and polymers under radiation, 17: 10715
**DZIUNIKOWSKI, Bohdan,** Determination of Pb in ore, 17: 10564

## E

**EARLE, Wilton R.,** Radiation response in tissue culture, 17: 10429
**EASLEY, J. W.,** Radiation damage to semiconductor devices, 17: 11267 (TID-15959)
**EASON, H. O.,** Neutron production from D plasma, 17: 11866
**EBATA, Takeshi,** Double $\pi^0$ photoproduction, 17: 11565
**EBEOGLU, D. B.,** Transients in pulsed moderators, 17: 11597 (TID-16085)
**ECKER, G.,** Non-contracting positive column under negative ion effect, 17: 11873
**ECKER, G.,** Theory of contraction of positive columns, 17: 11874
**EDA, Bunzo,** Radiation effects on $CCl_4$ solutions, 17: 10709
**EDWALL, B.,** Determining TBP content of kerosene-based extraction, 17: 10536 (NP-12398)
**EDWARDS, Arthur L.,** HARC and HEART THROB—programs for temperature distributions, 17: 10606 (UCRL-7069)
**EGELSTAFF, P. A.,** Creep properties of Mg–Cd alloy, 17: 11179 (AERE-M-1149)
**EHLER, A. W.,** Prog. rpt. on $H_3^+$ dissociation, 1/63, 17: 10604 (TID-17724)
**EICHELBERGER, J. F.,** Prog. rpt. on research, 8/62, 17: 10239 (MLM-1140)
**EICHER, H.,** Electric quadrupole moment of Fe-57, 17: 11759
**EICHHORN, E. L.,** Self-consistent wave function for Yb, 17: 11394
**EICHINGER, R. L.,** Vibratory and swage compaction of fuel rods, 17: 11151 (CEND-153(Vol.I)(p.149-62))
**EICHLER, Joerg,** Siegert theorem for β transitions, 17: 11758
**EILAND, H. M.,** Abundance of 1.43-Mev γ ray of Cs-138, 17: 11621 (KAPL-M-HME-6)
**EINSPRUCH, Norman G.,** Superconducting Nb–Zr alloys, 17: 11400
**EISENBERG, Y.,** Annihilation of antibaryons, 17: 11547
**ELDERKIN, C. E.,** Atmospheric physics, 17: 10848 (HW-73337(p.1-28))
**ELLEMAN, T. S.,** Radiation effects in reactor ceramics, 17: 11125
**ELLINGER, Friedrich,** Effects of spleen extract treatment on hematopoietic tissues of irradiated guinea pigs. I., 17: 10369
**ELLINGER, Friedrich,** Effects of spleen extract treatment on hematopoietic tissues of irradiated guinea pigs. II., 17: 10370
**ELLIOTT, R. M.,** Analysis of solids by mass spectrometry, 17: 10943
**EL-NESR, M. S.,** Half life of first excited state in Pr-143, 17: 11689
**ELSEA, A. R.,** Electron microscopic fractography, 17: 11083 (DMIC-Memo-161)
**ELYAN, V. V.,** Coherent electron radiation in synchrotron, 17: 11770 (BNL-767(p.100-5))
**EMEL'YANOV, V. S.,** Iodide refining of Nb, 17: 10635
**EMMETT, M. B.,** IBM-7090 subroutine package for making logarithmic and semilogarithmic graphs, 17: 11067 (ORNL-TM-430)
**EMRICH, Barry R.,** Literature survey on selected boride compounds, 17: 10579 (ASD-TDR-62-873)
**ENDEBROCK, R. W.,** Reactor Materials, Vol. 5, No. 3, 1962, 17: 11123
**ENDEBROCK, R. W.,** Reactor Materials, Vol. 5, No. 4, 1962, 17: 11124
**ENGELHARD, Hermann,** Effects of OH and H on diluted aqueous solutions, 17: 10717
**ENGELKE, W. T.,** Thermal conductivity and expansion of Pt alloys, 17: 11199 (UCRL-13061)
**ENGELMANN, F.,** Nonlinear effects from Vlasov's equation, 17: 11848
**ENGELMANN, F.,** Radiation losses from hot spherical plasma, 17: 11855
**ENGLAND, A. C.,** Neutron production from D plasma, 17: 11866
**ENGSTROEM, Arne,** Distribution of Pu in mice, 17: 10260
**EPSTEIN, Saul T.,** Hypervirial theorems for scattering theory, 17: 11909
**ERICSON, T.,** Pion capture for shell-model studies, 17: 11687
**ERIKSSON, Ingemar,** Isotope separation by gaseous diffusion, 17: 11060
**ERIKSSON, L. E. Gooran,** Dissolution of irradiated NaCl in $H_2O$, 17: 10612
**ERIKSSON, L. E. Gooran,** Proton resonance shifts in $H_2O$–$D_2O$, 17: 11342
**ERMAKOV, V. S.,** Temperature field in cylindrical fuel element, 17: 10810
**ERNST, W. S., Jr.,** Vibratory-compaction studies at ORNL, 17: 11146 (CEND-153(Vol.1)(p.61-74))
**ERROCK, G. A.,** Analysis of solids by mass spectrometry, 17: 10943
**ERWALL, Lars G.,** Isotopes in physical chemistry, 17: 10643
**ESCUDERO, J.,** Absorption factor in KI, 17: 11622 (NP-12439)
**EUBANK, H. P.,** Ion energy analyzer for plasma measurements, 17: 10897 (MATT-121)
**EVANS, E. A.,** Irradiation testing of powder-containing fuel, 17: 11154 (CEND-153(Vol.I I)(p.3-38))
**EVANS, G. Harlowe,** Separation of metal ions from mixtures by electro-chromatography, 17: 10753
**EVANS, R. M.,** Joining of Ni-base alloys, 17: 11163 (DMIC-181)
**EVANS, Robley D.,** Maximum permissible deposition of Pu in man, 17: 10337
**EVANS, Virginia J.,** Radiation response in tissue culture, 17: 10429
**EVERETT, Lyndon H.,** Free energy of formation of Ce and Pr monocarbides, 17: 10644
**EVERSON, W. A.,** Final rpt. on decontamination of radioactive components, 17: 12042 (MSAR-61-34)
**EVSTYUKHIN, A. I.,** Iodide refining of Nb, 17: 10635
**EWBANK, W. Bruce,** Hfs measurements on Ag-105, 17: 11706
**EWING, Maurice,** Air waves from nuclear explosions, 17: 10837

## F

**FAESSLER, Amand,** Gamma oscillations in deformed *gg* nuclei, 17: 11748
**FAIR, D. R. R.,** Instrumentation in nuclear stations, 17: 10995
**FARBER, Milton,** Properties of Be compounds. I., 17: 10627
**FASSEL, Velmer A.,** Atomic absorption spectra of V, Ti, Nb, Sc, Y, and Re, 17: 10549
**FAULKNER, J. M.,** Welding of Nb alloys, 17: 11243
**FAUST, W. L.,** Hfs of metastable state of Kr-83, 17: 11692
**FAUSTOV, R. N.,** Regge poles and perturbation theory. II., 17: 11905 (JINR-E-1095)
**FAVRO, L. D.,** Polynomials encountered in distribution function of spacings, 17: 11063 (BNL-757)
**FEDERER, J. I.,** Separating grain-boundary and lattice diffusion effects in polycrystalline materials, 17: 11236
**FEDYUSHIN, B. T.,** Effect of electric field on γ luminescence of ZnS, 17: 11229
**FEENBERG, E.,** Elementary excitations in He-II, 17: 11422

**FEITELBERG-BLANK, V. R.**, Effect of cm waves on absorption of amino acids, chlorides, and $H_2O$ in stomach, 17: 10315
**FEIX, M.**, Nonlinear effects from Vlasov's equation, 17: 11848
**FELDMAN, M.**, Thymus in recovery of immunological reactivity following x irradiation, 17: 10412
**FENTON, A. W.**, Acidity meter for uranyl nitrate solutions, 17: 10972
**FERADAY, M. A.**, Cold swaging $UO_2$ in Zircaloy, 17: 11148 (CEND-153 (Vol.I)(p.89-124))
**FERBER, R. R.**, Formation of p-n junction by ion bombardment, 17: 10773 (ASD-TDR-62-428)
**FERGUSON, D. E.**, Preparation of oxide fuels for vibratory compaction, 17: 11144 (CEND-153(Vol.1)(p.23-38))
**FERGUSON, G. A., Jr.**, Spectrum from modified split reactor core, 17: 12030
**FERGUSON, I. F.**, Oxides based upon CaO and BeO, 17: 11194 (TRG-Report-408)
**FERRARI, E.**, Peripheral nucleon-nucleon collisions, 17: 11515
**FERRARO, J. R.**, Structural aspects of organophosphorus extractants, 17: 10748 (TID-17726)
**FERRETT, D. J.**, Broad-line nuclear magnetic resonance, 17: 10946
**FIALA, Jiri**, Effects of x irradiation on thymidine incorporation, 17: 10486 (TID-15931)
**FILE, J.**, Persistent current in superconducting solenoid, 17: 11404
**FILIPOV, A. T.**, Regge poles and perturbation theory. II., 17: 11905 (JINR-E-1095)
**FILIPPOV, M. T.**, Chlorination of Si-containing monomers and polymers under radiation, 17: 10715
**FINEMAN, Olle**, Two types of betameters, 17: 10980
**FINKEL, Miriam P.**, Toxicity of Pu in mice, 17: 10317
**FINLAY, Roger W.**, Neutrons from reaction $F^{19}(d,n)Ne^{20}$, 17: 11636 (TID-17720(p.8-14))
**FINOCCHIO, F.**, Ultrastructure of Purkinje cells in irradiated animals, 17: 10460
**FIOCCO, G.**, Thomson scattering from electron beam, 17: 11550
**FIORE-DONATI, L.**, Thymus in recovery of immunological reactivity following x irradiation, 17: 10412
**FIRSTENBERG, H.**, Wet steam as reactor coolant, 17: 11965 (UNC-5008-I)
**FISCHER, E.**, Automatic closed orbit control, 17: 11811 (NP-tr-932)
**FISCHER, J.**, Fluoride volatility processing of enriched fuels, 17: 10744 (TID-13765)
**FISCHER, W.**, Mobility of Tl isotopes in molten TlCl, 17: 10647
**FISENNE, Isabel M.**, Radium-226 in diet in U. S. cities, 17: 10530 (ANL-6637(p.85-95))
**FISHER, John C.**, Elementary particle classification based upon massless Dirac field, 17: 11537
**FISHER, Roy W.**, Thermal efficiency of coated annular fins, 17: 10796 (IS-571)
**FITCH, C. E.**, Ultrasonic Lamb-wave propagation models for non-destructive testing, 17: 11304 (HW-75499)
**FITCH, S. H.**, Thermoelectric converter for SNAP, 17: 11314 (NAA-SR-7288)
**FITZSIMMONS, W. D. C.**, Irradiation of hydraulic rabbit specimens, 17: 11256 (CRFD-1119)
**FIUTAK, J.**, Multipole expansion in quantum theory, 17: 11350
**FLANAGAN, T. P.**, Glass scintillators, 17: 10965
**FLANAGAN, Ted B.**, Solubilities of H and D in Pt–Pd alloys, 17: 10632
**FLEISCHMANN, Hans H.**, Small-angle theory of multiple scattering, 17: 11573
**FLEISHER, V. G.**, Monomolecular P-32 source, 17: 10713
**FLEISHMAN, D. G.**, Statistical processes in scintillation counters, 17: 11041
**FLETCHER, E. Royce**, Nuclear bomb effects computer, 17: 10845 (CEX-62.2)
**FLETCHER, W.**, Determination of isotopic abundance of U, 17: 10970
**FLIEDNER, T. M.**, Bone marrow cell transfusions, 17: 10292 (BNL-6106)
**FLIEDNER, T. M.**, Clearance of Fe-59 from plasma after total-body irradiation, 17: 10413
**FLORKOWSKI, Tadeusz**, Determination of Pb in ore, 17: 10564
**FLOTOW, Howard E.**, Thermodynamic properties of $ZrH_2$, $ZrD_2$, $YH_2$, and $YD_2$, 17: 10597 (TID-15795)
**FOGEL, Ya. M.**, Thermionic emission of metals in different gases, 17: 11435
**FOJTIK, M.**, Extraction of Cs tetraphenyl borate, 17: 10757
**FOLDZINSKA, Aleksandra**, Determination of As in Zn, 17: 10563
**FORBERG, Sovald**, Cross section for $Ca^{44}(n,p)K^{44}$ and $Ca^{44}(n,p)K^{44}$, 17: 11651
**FORD, Edwin F.**, Pyrolytic graphite in rocket motors, 17: 11076 (AD-278371)
**FOREMAN, Harry**, Acceleration of excretion of actinide elements, 17: 10335
**FOREMAN, Harry**, Plutonium uptake by bone, 17: 10331
**FOREMAN, Harry**, Radioactive contamination of the skin, 17: 10494
**FORRAT, F.**, Uranates of Co and Mn, 17: 10633
**FORRESTER, J. D.**, Crystal structure of $KH_2F_3$, 17: 10608 (UCRL-10197)
**FORSBERG, H. G.**, Moisture determination by beta-ray transmission, 17: 10981
**FORSTER, E. G., Jr.**, Seebeck coefficient apparatus, 17: 11316 (NAA-SR-Memo-6741)
**FOSTER, James N.**, Properties of Be compounds. I., 17: 10627
**FOSTER, M. S.**, Helium-purification for inert-atmosphere boxes, 17: 10772 (ANL-6652)
**FOUCHER, Roger**, Internal conversion and *L* fluorescence in Pa-234, 17: 11657
**FOWLER, Earle C.**, Determination of branching ratio $\Gamma(\eta \to \pi^+\pi^-\gamma)/\Gamma(\eta \to \pi^+\pi^-\pi^0)$, 17: 11552
**FOWLER, T. K.**, DCX-2 performance curves, 17: 11835 (ORNL-3387)
**FOX, George A.**, Improved methods for work in radiation zones in production reactors, 17: 10854 (HW-SA-2565)
**FOYE, William O.**, Antiradiation Compounds. II. Dithiocarbamates, 17: 10428
**FRAHM, J.**, Isomeric shift in Fe-57, 17: 11691
**FRAME, Harlan D., Jr.**, Separation of metal ions from mixtures by electro-chromatography, 17: 10753
**FRANK-KAMENETSKII, D. A.**, Magnetic sound in plasma with thermal motion. I., 17: 11878
**FRANKLIN, Mary E.**, Nuclear bomb effects computer, 17: 10845 (CEX-62.2)
**FRANKLIN, N. L.**, Striking a balance in U fuels, 17: 11968
**FRANKOWSKI, Waclaw**, Hazards evaluation for reactors, 17: 11973
**FREEMAN, P. I.**, Cohesive and surface energies of Th and U dioxides, 17: 11217
**FREEMAN, R. S.**, Closed extensions of second order, 17: 11072 (UCRL-6648-T)
**FREESTONE, R. M., Jr.**, Mobile radiation measurement laboratory, 17: 10877
**FREISER, Henry**, Polarography of Nb–EDTA complexes, 17: 10544
**FRENCH, Samuel W.**, Effect of $D_2O$ on ectromelia viral infection, 17: 10285
**FREULICH, H.**, Ion sources with plasma contraction by inhomogeneous field, 17: 11777 (BNL-767(p.224-53))
**FREYER, B.**, Cortisone action in radiation syndrome, 17: 10268
**FRIED, Joan F.**, Removal of hydrolyzable radioelements, 17: 10523 (ANL-6637(p.5-8))
**FRIEDLANDER, G.**, Excitation and charge dispersion in proton fission of U, 17: 11725
**FRIEDMAN, A. M.**, Nuclear properties of Eu-145, Eu-146, Eu-147, Gd-146, and Gd-147, 17: 11719
**FRIEDMAN, E.**, Measuring thermalization parameters, 17: 11605
**FRIEDMAN, H. A.**, Phase equilibria in system NaF–$ThF_4$–$UF_4$, 17: 11216
**FRIEDMAN, L.**, Excitation and charge dispersion in proton fission of U, 17: 11725
**FRIEDMAN, M. G.**, Flow distribution across PWR core, 17: 11992 (WAPD-PWR-TE-93)
**FRIEMAN, Edward A.**, Theory of irreversible processes, 17: 11832 (MATT-106)
**FRIESER, H.**, Sulfur sensitization of emulsions, 17: 10649
**FRIGERIO, G.**, Cold swaging of $UO_2$, 17: 11152 (CEND-153(Vol.I)(p.163-9))
**FRIGERIO, G.**, Prog. rpt. on swaging $UO_2$, 7/61–6/62, 17: 11164 (EURAEC-412)
**FRITZ, James S.**, Cation exchange in acetone–$H_2O$–HCl, 17: 10733 (IS-466)
**FRITZ, James S.**, Separation of divalent metal ions from rare earths, 17: 10734 (IS-508)
**FRIZZI, G.**, Radioinduced mutations in *Anopheles maculipennis*, 17: 10385
**FROBEN, Friedrich Wilhelm**, Effect of OH and H on diluted aqueous solutions, 17: 10717

**FROEHNER, Friedrich H.**, Negative fission product ions, 17: 11746
**FROMM, Earle O.**, High-temperature irradiation test of $UO_2$ fuels, 17: 11254 (BMI-1608)
**FROST, Thomas T.**, Behavior in rat after cranial x irradiation, 17: 10430
**FRUIN, Robert C.**, Intragastric irradiation with Ru–$Rh^{106}$, 17: 10367 (TID-17727)
**FRYE, Graham**, Two Pomeranchuk-Regge trajectories, 17: 11915
**FUCHS, H.**, Spectra of neutrons from $C^{13}(\gamma,n)C^{12}$ and $O^{18}(\gamma,n)O^{17}$, 17: 11755
**FUCHS, H.**, Spectra of photoneutrons from O-18 and N-14, 17: 11756
**FUECHTBAUER, W.**, X irradiation of chloroplasts and effect of TPN reduction, 17: 10458
**FUJII, A.**, Muon capture in H, 17: 11480 (LNF-62/109)
**FUJII, S.**, Resonance peaks in the (p,n) reactions, 17: 11681
**FUJITA, F. I.**, Resonance peaks in the (p,n) reactions, 17: 11681
**FUKAWA, Mineo**, Pion production from $\nu + N$ or $\bar{\nu} + N$ collisions. I., 17: 11563
**FUKUDA, Nobuyuki**, Perturbation expansions in many-body problem, 17: 11416
**FUKUSHIMA, Kenji**, Perturbation expansions in many-body problem, 17: 11416
**FULLER, D. D.**, Development of gas-lubricated bearings, 17: 10792 (TID-17756)
**FULLER, D. D.**, Prog. rpt. on gas-lubricated bearings for turbomachinery, 6–8/62, 17: 10781 (TID-17311)
**FULLWOOD, R.**, Polarization of neutrons from photodisintegration of D, 17: 11551
**FULMER, C. B.**, Proton scattering by Ni-64 and Zn-64, 17: 11643 (UCRL-6930)
**FUMAGALLI, E.**, Hepatic function in cancer patients, 17: 10464
**FUNG, P.**, Photodecomposition of organic acids, 17: 10697
**FURNBERG, C.**, Characteristics of linear variable differential transformer gage head, 17: 10904 (SCTM-100-62-81)

# G

**GABAY, J. J.**, Environmental levels of Ra, 17: 10529 (ANL-6637(p.59-84))
**GABOVICH, M. D.**, Oscillations of plasma in a pulsed electrodeless discharge, 17: 11892
**GABOVICH, M. D.**, Oscillation of ions near potential minimum, 17: 11441
**GABOVICH, M. D.**, Oscillations excited in plasma by an electron beam, 17: 11871
**GAEUMANN, Tino**, Combination of gas chromatograph with mass spectrograph, 17: 10558
**GALAND, P.**, Metabolism of barley seedlings. III. Effect of x rays, 17: 10456
**GALE, R. H.**, Fabrication of $UO_2$ elements by 'vibswage' process, 17: 11150 (CEND-153(Vol.I)(p.137-47))
**GALLMANN, A.**, Helium-3 reactions on B-11 and N-14, 17: 11721
**GALLUCCI, E.**, X-ray effects on Drosophila recessive lethals, 17: 10392
**GALLUCCI, V.**, Radiation effects on collagens. III., 17: 10465
**GALSTER, S.**, Resolving power and solid angle of particle spectrometers. I., 17: 10895 (KFK-113)
**GAMBILL, W. R.**, Heat transfer of ethylene glycol, 17: 10808
**GANDOLFO, F. W.**, Reprocessing studies on irradiated UC reactor fuel, 17: 10736 (NAA-SR-7511)
**GARABEDIAN, H. V.**, Supercritical water reactor shield, 17: 11988 (PWAC-100)
**GARBER, H. J.**, Producing spherical Be particles, 17: 11101 (NUMEC-P-49)
**GARDNER, T. Estelle**, Thermodynamic properties of Cs chloride iodide, 17: 10584 (BM-RI-6157)
**GARNER, F. H.**, Heat and mass transfer between solid wall and fluid stream, 17: 10790 (AERE-R-4197)
**GARRALDA, Barbara B.**, Separation of divalent metal ions from rare earths, 17: 10734 (IS-508)
**GARY, John**, Computation of hydrodynamic flows, 17: 11324 (NYO-9603)
**GARY, John**, Finite difference schemes for equations hydrodynamics, 17: 11323 (NYO-9188)
**GASHEV, M. A.**, Characteristics of 4-6 Bev electron synchrotron, 17: 11766 (BNL-767(p.67-74))
**GASTEIGER, E. L.**, Prog. rpt. on fission product metabolism, 4/62–1/63, 17: 10310 (TID-17789)
**GASTUCHE, Marie-Claire**, Crystallization of Mg and Al hydroxides, 17: 10619
**GATTO, R.**, Classification of lepton currents, 17: 11479 (LNF-62/98)
**GATTO, R.**, Higher symmetry for EM and weak transitions, 17: 11477 (LNF-62/94)
**GATTO, R.**, Two neutrinos, 17: 11478 (LNF-62/97)
**GAUNT, J.**, Phase equilibrium for $UO_2(NO_3)_2$–$HNO_3$–$H_2O$, 17: 10615
**GAUSSENS, J.**, Cost analysis of nuclear kilowatt hour, 17: 10250
**GAUTAM, Vinod Prakash**, Branching ratios in isobar model for $K^-$-p, 17: 11560
**GAUVENET, A.**, Permissible performance limits of fuel elements in graphite–$CO_2$ reactors, 17: 11999 (AEC-tr-5610)
**GAUVIN, Henri**, Emission of $\alpha$ particles in spallation reactions, 17: 11663
**GAUVIN, Hervey P.**, Transmission of thermal radiation from nuclear detonations, 17: 11298 (AFCRL-62-456)
**GAVIN, D. A.**, Neutron captures in U-235 and natural B, 17: 11629 (TID-15884)
**GAVRILOV, K. A.**, Separation of Fm and Md, 17: 10735 (JINR-P-1075)
**GAVRILOVSKII, B. V.**, Polarization of charged particles, 17: 11815
**GAZDIK, M. F.**, Kinetic energy release in deuteron fission of U-238, 17: 11646 (UCRL-10193)
**GAZDIK, M. Frances**, Cross section and recoil studies of proton reactions with U-238, 17: 11726
**GEBALLE, T. H.**, Intermediate isotope effect of Mo and $Mo_2Ir$, 17: 11375
**GEDAYLOO, T.**, Computer program for analysis of complex $\beta$ spectra, 17: 11443
**GEISSLER, Georg**, Influence on pyruvic acid kinase by radiation-conditioned electrolytic displacement, 17: 10469
**GEITHOFF, D.**, Production of Si-32 by a (t,p) process, 17: 11738
**GEL'D, P. V.**, Carbon monoxide reduction of $Nb_2O_5$, 17: 10661
**GEMBRICZKY, M.**, Phosphorus-32 treatment of erythremia, 17: 10286
**GEMMELL, L.**, Transport of fission products through soil, 17: 10820 (BNL-6554)
**GENDRIN, Roger**, Effect of high-altitude explosion on earth-ionosphere cavity, 17: 10828
**GENIN, R.**, Thermal absorption and scattering cross sections of natural Ne, 17: 11620 (EANDC(E)-10.U)
**GENTNER, W.**, Investigations on stone meteorites, 17: 10839
**GEORGE, L. A., II**, Combined toxic effects of Pu plus x-ray, 17: 10318
**GEORGE, L. A., II**, Retention, translocation, and excretion of inhaled $Pu^{239}O_2$, 17: 10321
**GEORGI, J. R.**, Prog. rpt. on fission product metabolism, 4/62–1/63, 17: 10310 (TID-17789)
**GERKEN, J. M.**, Tungsten emitters for ion propulsion systems, 17: 11080 (ASD-TDR-62-756)
**GERKEN, J. M.**, Welding of Nb alloys, 17: 11243
**GERLING, E. K.**, Activation energy spectra in escape of Ar and He from minerals, 17: 10830
**GERSHKOVICH, I.**, Effect of radiation on synthesis of HCN, 17: 10704
**GHIGO, G.**, "AdA" accumulator ring for electrons and positrons, 17: 11820
**GHOSH, S. N.**, Secondary electron emission by $H^+$, $H^0$, $He^+$, and $He^0$ bombardments, 17: 11397
**GIACOMELLI, G.**, Decay mode $K^+ \to \pi^+ + \pi^+ + \pi^- + \gamma$, 17: 11523
**GIARDINA, G.**, Genetic experiments in Borek-Ryan effect, 17: 10382
**GIAVELLI, S.**, X ray effects on Drosophila recessive lethals, 17: 10392
**GIESE, W.**, Prog. rpt. on fission product metabolism, 4/62–1/63, 17: 10310 (TID-17789)
**GILBERT, P.**, Electromagnetic levitation of U, 17: 11092 (NAA-SR-Memo-615)
**GILLESPIE, A. B.**, Pulsed toroidal gas discharge apparatus, 17: 10982
**GILLET, Vincent**, Direct interaction in theory of nuclear reactions, 17: 11669
**GILMORE, R.**, Polarization in p-p scattering, 17: 11525
**GINDLER, James E.**, Alpha half lives of Po-216, At-217, and Rn-218, 17: 11632 (TID-16202)
**GINSBERG, Hans**, Determination limits for impurities in Al, 17: 10571
**GIORGI, A. L.**, Superconductivity of $Ta_2C$, $Nb_2C$, and $V_2C$, 17: 11391
**GIRARDI, Francesco**, Neutron activation analysis of Al, 17: 10546
**GJULLIN, C. M.**, Treatment of mosquito larvae with P-32, 17: 10423
**GLAUBER, Roy J.**, Photon correlations, 17: 11403

**GLAZKOV, N. P.**, Compressing He-3 into counters, 17: 10934
**GLAZOVA, V. V.**, Creep in Ti–Sn and Ti–Zr–Sn alloys, 17: 11211
**GLEISER, Chester A.**, Virus infection and x radiation, 17: 10427
**GLICK, Arnold J.**, Corrections to dielectric constant of degenerate electron gas, 17: 11861
**GLICKSTEIN, S. S.**, Properties of F-20, 17: 11694
**GLOBERSON, A.**, Thymus in recovery of immunological reactivity following x irradiation, 17: 10412
**GNAUCK, Gerhard**, Gas chromatography in rare gas production, 17: 10954
**GOCHENOUR, William S.**, Virus infection and x radiation, 17: 10427
**GODFREY, M.**, Two-group, three-region, fully reflected cylindrical reactor program for IBM 1620, 17: 11933 (AAEC/E-101)
**GODIN, Edward E.**, High repetition rate blocking oscillator, 17: 10906 (TID-15312)
**GOEDDEL, Walter V.**, Boron carbide–graphite nuclear control-rod material, 17: 11085 (GA-3064)
**GOERING, Harlan L.**, Deuterium exchange of aryl 2-octyl sulfones, 17: 10670
**GOERLICH, P.**, Coloring of synthetic $CaF_2$ crystals, 17: 10640
**GOETTING, Hans**, Baryte as radiation protection material, 17: 11205
**GOLAND, A. N.**, Observation of $Li^6(n,\alpha)H^3$ reaction, 17: 11615 (BNL-6082)
**GOLANT, V. E.**, Diffusion of charged particles in dense plasma, 17: 11880
**GOLANT, V. E.**, Diffusion decay of plasma. III., 17: 11890
**GOLDBERG, David**, Test of Feynmann–Gell-Mann theory of $\beta$-decay, 17: 11641 (TID-17720(p.90-7))
**GOLDBERG, M. D.**, Lithium-6 and $Li^6(n,2n)$ cross sections, 17: 11722
**GOLDENFELD, I. V.**, Automatic scanning of mass spectrometer magnetic field, 17: 10933
**GOLDFARB, L. J. B.**, Target polarization effects, 17: 11662
**GOLDIN, L. L.**, Design considerations for proton synchrotron, 17: 11767 (BNL-767(p.75-83))
**GOLDIN, L. L.**, Magnetic measurements in accelerator, 17: 11762 (BNL-767(p.1-31))
**GOLDMAN, Robert**, Coulomb interactions in strong magnetic field. I., 17: 11538
**GOLDSTEIN, L.**, Prog. rpt. on high-density plasmas, 9/15–12/15/61, 17: 11826 (AD-273961)
**GOLOVATENKO, R. T.**, Uranyl nitrate extraction, 17: 10770
**GOLOVIN, A. E.**, Delay system for neutron time-of-flight spectroscopy, 17: 11036
**GOOD, Robert A.**, Lympho-reticular cells in lasting tolerance, 17: 10289
**GOODMAN, Donald E.**, HOTSTICK—KARE axial power distribution program for Philco 2000, 17: 11951 (KAPL-M-RPC-5)
**GOPINATHAN, K. P.**, Preparation of neutron-deficient Nb-92, 17: 10714
**GORDON, Albert S.**, Hematopoietic studies in x-irradiated newborn rats, 17: 10368
**GORDON, B.**, Excitation and charge dispersion in proton fission of U, 17: 11725
**GORELIK, L. L.**, Separate measurements of energy losses in plasma, 17: 11893
**GORELIK, L. O.**, Loss of plasma through magnetic aperture of traps, 17: 11841 (AEC-tr-5620)
**GORSKA, Zofia**, Effects of radiation on aliphatic polyethers, 17: 10678 (PAN-306/XVII)
**GOUWENS, P. R.**, Prog. rpt. on 2400°F forging die systems, 9–12/62, 17: 11081 (ASD-TR-7-886(Vol.VII))
**GOVORKOV, B. B.**, Gamma recording by bremsstrahlung beam, 17: 11555
**GOWARIKER, V. R.**, Heat and mass transfer between solid wall and fluid stream, 17: 10790 (AEFE-R-4197)
**GOWOREK, Tomasz**, Pulse amplifier for scintillation spectroscopy, 17: 11032
**GRAEBNER, Herbert**, Radiation protection with butazolidine metabolite I Tanderil. I., 17: 10472
**GRAY, A. L.**, Design of neutron-sensitive detectors, 17: 10986
**GREBINNIK, V. G.**, Hydrogen–D bubble chamber in magnetic field, 17: 10930
**GRECO, S.**, Modifications of neurons of Gasser ganglion, 17: 10461
**GRECO, S.**, Picture from irradiation of brain in rats, 17: 10459
**GRECO, S.**, Ultrastructure of Purkinje cells in irradiated animals, 17: 10460
**GREEN, R. E.**, Lattice parameters for NPD and CANDU fuel elements in $D_2O$, 17: 11939 (CRL-75)
**GREENBAUM, Michael A.**, Properties of Be compounds. I., 17: 10627
**GREENBERG, E.**, Detection of bone metastases, 17: 10344
**GREENDALE, A. E.**, System for rapid handling of irradiated solution, 17: 10784 (USNRDL-TR-601)
**GREENE, Margaret W.**, Milking systems for radioisotope separation, 17: 11050 (BNL-6697)
**GREGOIRE, M.**, Anomalous diffusion in a plasma, 17: 11857
**GREIDER, K. R.**, Approximation in scattering theory, 17: 11492 (TID-16044)
**GREINER, Walter**, Gamma oscillations in deformed *gg* nuclei, 17: 11748
**GREISS, Frank C.**, Complications of radiation therapy for cervical carcinoma, 17: 10449
**GRENIER, C. G.**, Electron transport in Zn at liquid-He temperatures, 17: 11378
**GRESKY, A. T.**, Comparison of DBPP and DSBPP with TBP for recovery of U and Th, 17: 10738 (ORNL-3374)
**GRIFFITH, G. L.**, Magnetohydrodynamic power generation, 17: 12002
**GRIFFITHS, D. J.**, Faraday rotation studies of PMR in Nd ethylsulfate, 17: 10617
**GRIFFY, T. A.**, Partial-wave analysis of electron scattering. II., 17: 11710
**GRIGOROV, N. L.**, Energetic particle interactions with atomic nuclei at mountain altitudes, 17: 11454
**GRITZNER, V. B.**, Short-arc welding of Hastelloy N(INOR-8), 17: 11169 (Y-1409)
**GRODZINS, L.**, First $2^+$ states in even-even nuclei, 17: 11674
**GRONEMEYER, Fred C.**, Sodium-cooled reactors: Hallam, 17: 12003
**GROOT, Cornelius**, Corrosion in energy conversion systems, 17: 11133 (TID-16561)
**GROSSETETE, Bernard**, Elastic electron-deuteron scattering and neutron EM structure, 17: 11505
**GROSSMAN, Ronald A.**, Determination of branching ratio $\Gamma(\eta \to \pi^+\pi^-\gamma)/\Gamma(\eta \to \pi^+\pi^-\pi^0)$, 17: 11552
**GROSVENOR, D.**, Contamination and decontamination studies related to BWR, 17: 11959 (TID-15779)
**GROTOWSKI, K.**, Elastic scattering angular distributions, 17: 11688
**GROVE, G. R.**, Prog. rpt. on research, 8/62, 17: 10239 (MLM-1140)
**GROVES, Thomas H.**, Elastic scattering of $\Lambda$ hyperons from protons, 17: 11533
**GRUHL, Wolfgang**, Stress corrosion of Al–Zn–3% Mg, 17: 11139
**GUBERMAN, Sh. A.**, Similarity theory and radiometry of bore holes, 17: 10842
**GUCZI, Laszlo**, Radioisotopes in food research, 17: 10882
**GUERIN, M.**, Appearance of lymphoid tumors in mice, 17: 10406
**GUERS, K.**, Determination of excited state lifetime with masers, 17: 10651
**GUNNING, Harry E.**, Quenching of Hg resonance radiation, 17: 10685
**GUNTER, B. D.**, Beta and $\alpha$ activity in urine, 17: 10525 (ANL-6637(p.23-8))
**GUNTER, E. J.**, Prog. rpt. on gas-lubricated bearings for turbomachinery, 6–8/62, 17: 10781 (TID-17311)
**GUNTER, E. J., Jr.**, Development of gas-lubricated bearings, 17: 10782 (TID-17756)
**GUON, J.**, Reprocessing studies on irradiated UC reactor fuel, 17: 10736 (NAA-SR-7511)
**GUPTA, Asim K.**, Formation constants of rare earth complex species, 17: 10501 (IS-458)
**GUPTA, Yogendra Mohan**, Branching ratios in isobar model for $K^-$-p, 17: 11560
**GUSAROV, I. I.**, Determining air pollution by Rn daughter products, 17: 10560
**GUSMANO, E. A.**, Kinetics of Ca-47 and Sr-85 in man, 17: 10293 (BNL-6108)
**GUSTAVS, A.**, Isomeric shift in Fe-57, 17: 11691
**GUSTOV, G. K.**, Characteristics of 4-6 Bev electron synchrotron, 17: 11766 (BNL-767(p.67-74))
**GUTHRIE, J. W.**, Mass-spectrometer gas analysis, 17: 10537 (TID-15724)
**GUTKIN, T. I.**, Ion sources with plasma contraction by inhomogeneous field, 17: 11777 (BNL-767(p.224-53))
**GUTNER, B. H.**, Electronic systems for proton synchrotron, 17: 11763 (BNL-767(p.32-47))
**GUY, A. G.**, Anomalies in thermal expansion of dilute solid solutions, 17: 11238

**GUZMAN, I. Ya.**, Beryllium oxide porous ceramics, 17: 11226
**GVUZD, E.**, Separation of Fm and Md, 17: 10735 (JINR-P-1075)

# H

**HAAG, D.**, Spectra of neutrons from $C^{13}(\gamma,n)C^{11}$ and $O^{16}(\gamma,n)O^{15}$, 17: 11755
**HAAG, J. N.**, Nuclear alignment of Ce-137m, Ce-137, Ce-139, Ce-141, and Ce-143, 17: 11705
**HAAR, D. Ter**, Poles of Green functions, 17: 11517
**HAAS, P. A.**, Preparation of oxide fuels for vibratory compaction, 17: 11144 (CEND-153(Vol.1)(p.23-38))
**HAAS, P. A.**, Prog. rpt. on chemical technology, 6/62, 17: 10741 (ORNL-TM-313)
**HAAS, P. A.**, Prog. rpt. on chemical technology, 1/61, 17: 10743 (ORNL-TM-457)
**HAAS, R.**, Decay of Cl-38 isomers, 17: 11747
**HADLEY, James W.**, TORY-IIA—nuclear ramjet test reactor, 17: 11990 (UCRL-5484(Del.))
**HAEFELE, W.**, Development of fast breeder reactor, 17: 12021
**HAEUFGLOECKNER, Helmut**, X-ray bremsstrahlung in a betatron, 17: 11821
**HAGG, E. L.**, Electron density at 1000 km, 17: 11452
**HAHN, H.**, Deflecting mode in circular iris-loaded waveguide of r-f particle separator, 17: 11783 (BNL-6670)
**HAINS, F. D.**, Magnetogasdynamic source, 17: 11830 (D1-82-0166)
**HAISSINSKY, M.**, Chemical actions caused by nuclear processes, 17: 10720
**HAISSINSKY, M.**, Radiolysis of aqueous solutions of Te. I., 17: 10693
**HAJDUKOVIC, S.**, Effect of methysergide and x irradiation on rats, 17: 10418
**HALL, K. L.**, Prog. rpt. on radiation stability of organic fluids, 17: 11268 (TID-16999)
**HALL, W. C.**, PM-3A hazards report corrections, 17: 11985 (MND-M3A-2496(Vol.I)(Add.))
**HALLDEN, Naomi A.**, Radium-226 in diet in U. S. cities, 17: 10530 (ANL-6637(p.85-95))
**HAMILTON, Howard B.**, BEI values of adolescents exposed to Nagasaki bomb, 17: 10371
**HAMLIN, Alice**, Electron microscopic autoradiography with $H^3$-labeled cells, 17: 10284
**HAND, L. N.**, Experimental investigation of pion electroproduction, 17: 11543
**HANDLER, J. A.**, Determining tritium in tissues, 17: 10552
**HANDLEY, Thomas H.**, Tri-n-butylphosphine sulfide as organic extractant, 17: 10754
**HANDS, J. D.**, Rapid assay of Cs in milk, 17: 10551
**HANKEL, R.**, Wet steam as reactor coolant, 17: 11965 (UNC-5008-I)
**HANNERZ, K.**, Aluminum alloys as cladding materials, 17: 11120
**HANSBURY, Elizabeth**, Thin layer chromatography apparatus, 17: 10926
**HANSEN, Niels**, Metallurgical laboratory at Risø, 17: 11121
**HANSEN, Niels**, Solid state particle detectors, 17: 11009 (TID-16206)
**HANSON, D. L.**, Ergodic transformations, 17: 11068 (TID-15948)
**HANSON, I. C.**, High-capacity mixer-settlers. I., 17: 10786
**HARBOTTLE, Garman**, Thermal annealing of recoil Br-82, 17: 10673 (BNL-6535)
**HARDING, R. D.**, Rapid assay of Cs in milk, 17: 10551
**HARDY, Harriet L.**, Beryllium disease: a continuing diagnostic problem, 17: 10313
**HARDY, J., Jr.**, Effective U-238 resonance capture integrals, 17: 11667
**HARDY, J., Jr.**, Equivalence relations for effective resonance integrals, 17: 11668
**HARFORD, Carl G.**, Electron microscopic autoradiography with $H^3$-labeled cells, 17: 10284
**HARIGEL, Gert**, X-ray bremsstrahlung in a betatron, 17: 11821
**HARLAN, H. B.**, Short-arc welding of Hastelloy N(INOR-8), 17: 11169 (Y-1409)
**HARLEY, John H.**, Radium-226 in diet in U. S. cities, 17: 10530 (ANL-6637(p.85-95))
**HARLOW, Francis H.**, Fluid dynamics and particle-and-force models, 17: 11310 (LA-2806)
**HARRIS, J. C.**, Prog. rpt. on nuclear physics, final, 11/50–9/62, 17: 11633 (TID-17534)
**HARRIS, W. B.**, Urine U excretion data, 17: 10305 (HASL-120)
**HART, J. F.**, Eigenfunctions and energy values of $2^3S$ states of He and He-like ions, 17: 11751
**HART, V. P.**, Bombardment of C-12 by Li-6 ions, 17: 11718
**HARTLEY, Craig S.**, Computer program for the Matano analysis of binary diffusion data, 17: 11301 (ASD-TDR-62-858)
**HARTMANN-BOUTRON, F.**, NMR modes in magnetic material. I., 17: 11379
**HARTWIG, G.**, Resolving power and solid angle of particle spectrometers. I., 17: 10895 (KFK-113)
**HASEGAWA, Kenji**, Effect of tensor force on photonuclear sum rule, 17: 11733
**HASLAM, R. N. H.**, Reaction $P^{31}(\gamma,n)P^{30}$, 17: 11653
**HATCH, L. P.**, Ball kiln calcination, 17: 12047 (TID-7646(p.37-42))
**HATCH, L. P.**, Uranium recovery from unirradiated fuel elements, 17: 10728 (BNL-6148)
**HATCH, L. P.**, Volatility reprocessing of reactor fuels, 17: 10730 (BNL-6195)
**HAUSER, Frank E.**, Dislocation concepts of strain rate effects, 17: 11198 (UCRL-10498)
**HAUSER, R.**, Extrusion of $UO_2$, 17: 11159 (CEND-153(Vol.II)(p.115-29))
**HAUTH, J. J.**, Fabrication of packed-powder fuels, 17: 11143 (CEND-153(Vol.1)(p.11-21))
**HAVAS, Peter**, Limit of quantum theory of radiation damping, 17: 11916
**HAVENS, W. W., Jr.**, Inelastic scattering of slow neutrons, 17: 11602
**HEAD, Charles**, Structure of liquid Hg, 17: 11232
**HEBERT, G. M.**, Phase equilibria in system NaF–$ThF_4$–$UF_4$, 17: 11216
**HECKLER, G. E.**, Photodecomposition of organic acids, 17: 10697
**HECKMAN, Harry H.**, Charge distributions for heavy ions at high velocities, 17: 11388
**HEDDLE, D. W. O.**, Polarization of electron impact radiation in He, 17: 11409
**HEIN, H. J.**, Fuel elements of $U_3O_8$–polyethylene, 17: 12027
**HEINZINGER, K.**, Mobility of Tl isotopes in molten TlCl, 17: 10647
**HEITKAMP, A. F., Jr.**, Abundance of 1.43-Mev $\gamma$ ray of Cs-138, 17: 11621 (KAPL-M-HME-6)
**HEJTMANEK, H.**, Integral equation of transport theory, 17: 11601
**HELELAE, T.**, Beam delineation in x-ray diagnostics, 17: 10273
**HELLSTROEM, S.**, Absolute activity measurements, 17: 10966
**HELM, F. H.**, Investigation of fast reactor systems, 17: 11461 (TID-17817)
**HELM, R. H.**, Dynamics of particle in field of tapered solenoid, 17: 11795 (SLAC-4)
**HELM, R. H.**, Focusing for Stanford two-mile accelerator, 17: 11793 (SLAC-2)
**HELMER, R. G.**, Computer program for analysis of complex $\beta$ spectra, 17: 11443
**HEMMER, P. Chr.**, Gamma emission from nuclei in crystals, 17: 11658
**HEMPELMANN, L. H.**, Plutonium in man, 17: 10338
**HENGLEIN, A.**, Gamma radiolysis of chlorobenzene, 17: 10716
**HENKES, W.**, Mass spectrometry of beams from condensed H, 17: 11428
**HENNIG, A.**, Radiation effects on B-12 solutions, 17: 10718
**HENTSCHEL, Hans-Juergen**, Axis temperature of cylindrical arcs in strong radiation, 17: 11427
**HERMAN, Jan A.**, X-ray-induced polymerization of vinyl iodide, 17: 11284
**HERMANN, K. O.**, Measurement of photoproton spectrum from C-12, 17: 11749
**HERNBORG, Gunnar**, Burnout conditions for flow of boiling $H_2O$ in vertical annuli, 17: 10789 (AE-100)
**HERRING, Conyers**, Calculating spin couplings at large distances, 17: 11420
**HERRING, D. F.**, Prog. rpt. on nuclear physics, final, 11/50–9/62, 17: 11633 (TID-17534)
**HERRING, G. M.**, Possible binding agent for Y, Am, and Pu, 17: 10332
**HERRING, J. P.**, Retention, translocation, and excretion of inhaled $Pu^{238}O_2$, 17: 10321
**HERRIOTT, James**, Growth of single crystals of Pb, Cd, and Bi, 17: 10502 (IS-542)
**HERSKOWITZ, I. H.**, Induced changes in female germ cells of Drosophila. VII., 17: 10415
**HERZBERG, G.**, Eigenfunctions and energy values of $2^3S$ states of He and He-like ions, 17: 11751
**HERZMANN, H.**, Radiation effects on B-12 solutions, 17: 10718

**HERZOG, W.**, Mobility of Tl isotopes in molten TlCl, 17: 10647
**HESS, J. M. C.**, Association constants of Cd and Cl ions in $NH_3$, 17: 10594 (TID-15741)
**HETHERINGTON, R.**, Control of steam-cooled reactor, 17: 10985
**HEWITT, R. R.**, Nuclear quadrupole interaction of Sb-121 and Sb-123, 17: 11385
**HIBOU, F.**, Helium-3 reactions on B-11 and N-14, 17: 11721
**HIDALGO, John U.**, Calibration of thyroid uptake systems, 17: 10343
**HIETBRINK, B. E.**, Radiation effects on pyridine nucleotide-linked dehydrogenase activity, 17: 10479 (NP-12251(p.12-21))
**HIETBRINK, Bernard E.**, Influence of chemical agents on irradiated enzyme, 17: 10480 (NP-12251(p.22-33))
**HIETBRINK, Bernard E.**, Radiation effects on thiophosphate-oxidizing enzyme system, 17: 10478 (NP-12251(p.1-11))
**HIGGINS, R. M.**, Fuel assembly and heat transfer for EGCR. I., 17: 11989 (TID-11604)
**HILL, F. B.**, Distribution of U and Ce between liquid Bi–Mg and NaCl–KCl–$MgCl_2$, 17: 10581 (BNL-639)
**HILL, R. W.**, Lithium-6 and $Li^7(n,2n)$ cross sections, 17: 11722
**HILLMAN, Manny**, Cross sections of 14.5-Mev neutron reactions in Ca-47 formation, 17: 11614 (BNL-6044)
**HILLMAN, Manny**, Milking systems for radioisotope separation, 17: 11050 (BNL-6697)
**HILTZ, R. H.**, Tungsten emitters for ion propulsion systems, 17: 11080 (ASD-TDR-62-756)
**HIMES, R. C.**, Semiconducting properties of rare earths, 17: 11296 (AD-278352)
**HIMLE, Arthur N.**, Flat-plate solar thermoelectric conversion panels, 17: 11300 (ASD-TDR-62-214)
**HINES, John**, Separation of actinides with nitric acid–methanol and EDTA, 17: 10771
**HINKLE, J. G.**, Prog. rpt. on gas-lubricated bearings for turbomachinery, 6–8/62, 17: 10781 (TID-17311)
**HIRSCHFELDER, Joseph O.**, Generalized momentum operators in quantum mechanics, 17: 11339 (WIS-AEC-34)
**HIRSCHFELDER, Joseph O.**, Virial theorem in scattering theory, 17: 11908
**HISKES, John R.**, Inverted cascades in neutral H beams, 17: 11407
**HITCHCOCK, Robert B.**, Tri-*n*-butylphosphine sulfide as organic extractant, 17: 10754
**HJERTBERG, Peter**, Instrumentation for power reactors, 17: 10996
**HLAVAY, E.**, Leukemia induced by x-ray irradiation and treatment, 17: 10258
**HOEBEL, M.**, Changes in standard solutions of I-131 upon aging, 17: 10682
**HOEGASEN, H.**, Eriksen transformation of particles with spin 0 and 1, 17: 11509
**HOELSCHER, H. E.**, Interfacial reactions with reference to metal corrosion, 17: 10601 (TID-15942)
**HOF, J. Van't**, Mitotic inhibition following x irradiation, 17: 10359 (HW-SA-2606)
**HOFFER, Thomas W.**, High-voltage dividers for image intensifier tubes, 17: 10907 (TID-15860)
**HOFMANN, F.**, Fuel element fabrication of $UO_2$ powders, 17: 11149 (CEND-153(Vol.I)(p.125-35))
**HOGASEN, H.**, Cini-Touschek transformation for Dimc particles, 17: 11508
**HOIGNE, J.**, Radiation-induced effects in MgO catalysts, 17: 10672 (BNL-6097)
**HOLBROW, C. H.**, Evaporation neutrons from protons on Rh, 17: 11631 (TID-16049)
**HOLCOMB, L.**, Electron beam intensity and position measurement at CEA, 17: 11797 (TID-16967)
**HOLLADAY, R. L.**, Prog. rpt. on HPD project, 7–9/62, 17: 11945 (GEAP-4096)
**HOLLAND, J. W.**, Performance of Cs thermionic diodes, 17: 11315 (NAA-SR-7661)
**HOLM, M. W.**, Self-consistent wave function for Yb, 17: 11394
**HOLMBERG, Karl Erik**, Isotopic effects in systems of amines and $CO_2$, 17: 10521
**HOLMES, W. G.**, Control of H in fabrication of $UO_2$ fuels, 17: 11158 (CEND-153(Vol.II)(p.101-14))
**HOLMES, W. G.**, Failures to $UO_2$ fuel tubes, 17: 11157 (CEND-153(Vol.II) (p.77-99))
**HOOD, R. R.**, Prog. rpt. on heavy water reactors, 11/62, 17: 11979 (DP-805)
**HOOTON, D. J.**, Nuclear and direct contributions to neutron polarization, 17: 11752
**HOPKINS, H. H., Jr.**, Active metal reduction of $PuCl_3$, 17: 10582 (HW-SA-1973)
**HOPPS, John A.**, Coronary arteriography by single x-ray exposure, 17: 10267
**HOPSON, J. E.**, Final rpt. on energy transfer in plasma, 17: 11836 (RADC-TDR-62-186)
**HOREN, D. J.**, Decay of Ba-131m, 17: 11713
**HORN, G. R.**, Evolution of $UO_2$ structure during irradiation of fuel rods, 17: 11260 (HW-SA-2650)
**HORNE, Thomas**, Cold encapsulation of Co, 17: 11176
**HORTON, R. W.**, Prog. rpt. on chemical technology, 6/62, 17: 10741 (ORNL-TM-313)
**HORTON, R. W.**, Prog. rpt. on chemical technology, 1/61, 17: 10743 (ORNL-TM-457)
**HOUGH, G. V.**, Burst element detection systems, 17: 10991
**HOULLIER, A.**, Radiolytic and thermal stability of terphenyls, 17: 10689
**HOVORKA, D. L.**, Weldability of metals, 17: 11166 (HW-SA-2527)
**HRYNKIEWICZ, Andrzej Z.**, Fast-slow coincidence circuit with time to pulse-height converter, 17: 11033
**HU, K. C.**, Improving pulse rise time, 17: 10924
**HUART, R.**, Metabolism of barley seedlings. III. Effect of x rays, 17: 10456
**HUBBARD, Edward L.**, Charge distributions for heavy ions at high velocities, 17: 11388
**HUBBARD, Kenneth**, Computer program for the Matano analysis of binary diffusion data, 17: 11301 (ASD-TDR-62-858)
**HUCHER, I.**, Extraction of U(IV) by phosphates and phosphonates, 17: 10745 (TID-15773)
**HUCK, C. E.**, Application to $UO_2$ calciner furnace of closed loop control system, 17: 10723
**HUDDLESTON, C. M.**, Differential dose albedo for $\gamma$ rays on concrete, 17: 11901 (NP-12455)
**HUEBNER, W.**, Ion mobility and electron accumulation in $N_2$, 17: 11047
**HUETTER, T.**, Radiative $\tau^+$ decay, 17: 11536
**HUFFSTUTLER, M. C., Jr.**, Crystal structure of $\beta'$ $Cu_{0.72}Al_{0.28}$, 17: 11195 (UCRL-9536)
**HUGHES, Ann M.**, Effect of $D_2O$ on ectromelia viral infection, 17: 10285
**HUGHES, B. G.**, Reactions of Nb(V) halides with pyridine, 17: 10500 (IS-385)
**HUGHES, G.**, Radiolysis of ferro- and ferri-cyanide solutions, 17: 10692
**HUGHES, L. A.**, Producing spherical Be particles, 17: 11101 (NUMEC-P-49)
**HUGHES, R. H.**, Polarization of optical radiation by electron impact on He, 17: 11396
**HUGHES-SCHRADER, Sally**, Kinetochore of the hemiptera, 17: 10404
**HULL, G. W., Jr.**, Intermediate isotope effect of Mo and $Mo_2Ir$, 17: 11375
**HULM, J. K.**, High-field superconducting solenoids, 17: 11349
**HUMBEL, F.**, Controllable ionization chambers, 17: 10967
**HUMBEL, F.**, Halogen counters in dose measurements, 17: 10961
**HUME, David N.**, Fluoride complexes of Hf, 17: 10600 (TID-15939)
**HUNTER, G. J.**, Apparatus for cylindrical graphite specimens, 17: 11934 (AERE-R-3453)
**HUNTER, Maxwell W., Jr.**, Single-stage spaceships, 17: 12038
**HUPP, E. W.**, Growth and sexual development of prenatally irradiated cattle, 17: 10422
**HURWITZ, H., Jr.**, Kinetics of low source reactor startups. I., 17: 11960 (TID-16142(Pt.I))
**HURWITZ, H., Jr.**, Kinetics of low source reactor startups, 17: 11961 (TID-16142(Pt.II))

## I

**ICHIKAWA, Yoshi H.**, Anomalous particle loss across magnetic field, 17: 11868
**IDA, Masakuni**, Collision of elementary particles, 17: 11566
**IDA, Masakuni**, Semi-classical picture for high-energy scattering, 17: 11925
**IGLEWSKI, Stanislaw**, Fast neutrons elastically scattered on Ca, 17: 11593 (PAN-354/I-A)
**IHRIG, H. K.**, Experiments with superconducting wire and solenoids, 17: 11335 (TID-17827)

**IKEDA, K.**, Resonance peaks in the (p,n) reactions, 17: 11681
**ILIESCU, C. C.**, Parameters of magnetic fields for instruments, 17: 10935
**ILJENKO, B. P.**, Magnetic areas in systems with helical magnetic field, 17: 11879
**IMAMURA, Hiroshi**, Measurement of concentration of pulverized coal in pneumatic conveyors by $\beta$ transmission, 17: 10881 (AEC-tr-5581)
**INDREAS, G.**, Control of cyclotrons operating with multiply charged ions, 17: 11818
**INFELD, Leopold**, Planck's constant and theory of red shift, 17: 11305 (IFT-1)
**INGRAM, M.**, Radiation inactivation of *Clostridium botulinum* spores in meat, 17: 10883
**INSLEY, Herbert**, Phase equilibria in system NaF–$ThF_4$–$UF_4$, 17: 11216
**IOLIN, E.**, Ionization of H atom close to threshold, 17: 10707
**IRVINE, W. R.**, Reaction of Li with $H_2O$ vapor, 17: 10622
**ISAAC, Gerhard J.**, Rat feeding studies with $\gamma$-irradiated foods, 17: 10350
**ISAKOFF, L.**, Prog. rpt. on heavy water reactors, 11/62, 17: 11979 (DP-805)
**ISRAEL, Gerhard W.**, Tritium concentration in rain, 1960-61, 17: 10840
**ISRAEL, S.**, Wet steam as reactor coolant, 17: 11965 (UNC-5008-I)
**ISSEROW, S.**, Prog. rpt. on power reactors, 8/62, 17: 11095 (NMI-7254)
**ISSEROW, S.**, Prog. rpt. on power reactors, 10/62, 17: 11096 (NMI-7256)
**ISSEROW, S.**, Prog. rpt. on power reactor program, 11/62, 17: 11097 (NMI-7257)
**ITABASHI, Kiyomi**, Double $\pi^0$ photoproduction, 17: 11565
**IVANII, G. M.**, De-excitation effect of x rays, 17: 11289
**IVANITSKII, P. G.**, Stripping reaction on Cr isotopes, 17: 11742
**IVANOV, Yu. (U.) S.**, Control system for beam in synchrotron, 17: 11764 (BNL-767(p.48-63))

## J

**JACKSON, H. W.**, Elementary excitations in He-II, 17: 11422
**JACKSON, Harris**, Safety in x rays, 17: 10875
**JACOBS, A.**, Energy deposition in polymers by radiation, 17: 11280
**JACOBSEN, W. R.**, Plutonium urinalysis procedure, 17: 10527 (ANL-6637(p.33-42))
**JACROT, B.**, Application of inelastic neutron scattering, 17: 11222
**JAEGER, G.**, Drift velocities of ions and electrons, 17: 11430
**JAIN, B. D.**, Gravimetric determination of La, Gd, and Y, 17: 10568
**JAKOWLEW, Ju. W.**, Determination of contaminations in P by neutron activation, 17: 10562
**JANOUSEK, S.**, Luminescence of AgCl crystals, 17: 10712
**JANOVEC, V.**, Mossbauer effect and ferroelectric properties of ionic crystals, 17: 10639
**JANSSEN, Earl**, Prog. rpt. on two-phase pressure losses, 8-11/62, 17: 10792 (GEAP-4148)
**JANTSCH, Erich**, Gas-cooled high-temperature reactor, 17: 11998 (AEC-tr-5484)
**JANZ, George J.**, Non-aqueous conductance data, 17: 10504 (NYO-9696)
**JARVIS, R. G.**, Close packed lattices in $H_2O$ and $D_2O$—spectrum, 17: 11940 (CRRP-895)
**JECH, C.**, Release of inert gas from ionic crystal, 17: 10638
**JEE, W. S. S.**, Failure of Pu to deposit in osteoid, 17: 10330
**JEE, W. S. S.**, Gingival ulceration induced in beagles, 17: 10296 (COO-226(p.35-49))
**JEE, W. S. S.**, Hyperossification in autogenous tibial transplants, 17: 10304 (COO-226(p.128-30))
**JEE, W. S. S.**, Long-term effects of Pu-239 in adult beagles, 17: 10303 (COO-226(p.95-127))
**JEE, W. S. S.**, Radioautographic distribution of Pu-239, 17: 10329
**JEE, W. S. S.**, Skeletal toxicity of Pu-239 in beagles, 17: 10320
**JEE, Webster S. S.**, Liver injury in beagles with Pu-239, 17: 10328
**JEE, Webster S. S.**, Radium dosimetry, 17: 10302 (COO-226(p.86-94))
**JEE, Webster S. S.**, Toxicity of Pu in skeletal tissues. I., 17: 10346
**JENKINS, R. J.**, Thermal diffusivity and heat capacity measurements, 17: 11200 (USNRDL-TR-599)
**JENNINGS, F. L.**, Development of radiation pneumonitis, 17: 10377
**JENSEN, C.**, Photodecomposition of organic acids, 17: 10697
**JENSEN, R.**, Photodecomposition of organic acids, 17: 10697
**JERONYMO, J. M. F.**, Excited states in N-14, 17: 11623 (NP-12496)
**JOBES, F. C.**, Heavy-ion detection system, 17: 11008 (TID-16174)
**JOBES, F. C.**, Uniformity of commercial foils, 17: 11104 (TID-16252)
**JOHNS, M. W.**, Decay of Pm-151, 17: 11652
**JOHNSON, C. E.**, Helium-purification for inert-atmosphere boxes, 17: 10772 (ANL-6652)
**JOHNSON, James E.**, Disassembly of high level Pu glove box systems, 17: 10866 (TID-16203)
**JOHNSON, John C.**, Transmission of thermal radiation from nuclear detonations, 17: 11298 (AFCRL-62-456)
**JOHNSON, Noah R.**, Decay of Re-184 isomers and level scheme in W-184, 17: 11717
**JOHNSON, Robert W.**, Electron requirements on bonds in metal borides, 17: 11306 (IS-473)
**JOLIVET, Andre**, General equations of particles with spin, 17: 11504
**JOLLY, M. S.**, Radioinduced mutations in *Anopheles maculipennis*, 17: 10385
**JOLY, R.**, Thermal absorption and scattering cross sections of natural Ne, 17: 11620 (EANDC(E)-10.U)
**JONES, D. C.**, Tumors of pancreas in irradiated and nonirradiated rat, 17: 10432
**JONES, K. W.**, Prog. rpt. on nuclear physics, final, 11/50–9/62, 17: 11633 (TID-17534)
**JONES, L. V.**, Prog. rpt. on research, 8/62, 17: 10239 (MLM-1140)
**JONES, Robert D., Jr.**, Solving one-group-diffusion-equation with variable coefficients, 17: 11590 (NP-12368)
**JONES, Robert T.**, Conformal coordinates with space-like motions, 17: 11354
**JONKE, A. A.**, Fluoride volatility processing of enriched fuels, 17: 10744 (TID-13765)
**JORDAN, Dona L.**, Thymic lymphoma incidence and longevity of female mice irradiated with neutrons or $\gamma$ rays, 17: 10360 (TID-15850)
**JORDAN, Joseph**, Prog. rpt. on fused salts, 8/16/61–12/31/62, 17: 10518 (TID-17823)
**JORDAN, P. L.**, Prog. rpt. on stress-corrosion cracking of high-strength alloys, 11/62, 17: 11099 (NP-12475)
**JUGLE, D. B.**, Solution of transition elements in liquid Al, 17: 10577 (ANL-FGF-292)
**JUNGHAHN, Lennart**, Adsorption of Pm-147 on metal surfaces, 17: 11244
**JUNKINS, R. L.**, Prog. rpt. on radiological research, 1-12/61, 17: 10847 (HW-73337)
**JURISSON, J.**, Flux trapping, 17: 11369
**JURKIEWICZ, Leopold**, Determination of Pb in ore, 17: 10564
**JURY, S. H.**, Electronic accounting devices for data logging, 17: 10903 (ORNL-TM-344)

## K

**KAALEN, M. C. A. C.**, Protection of tissue-culture cells against ionizing radiation. II., 17: 10493
**KACZMAREK, U.**, Effects of delayed neutrons on distribution curve of reactor, 17: 11949 (IKF-2)
**KACZMAREK, U.**, Testing of simple model for a BWR, 17: 12024 (IKF-3)
**KAHALAS, Sheldon L.**, Coupling of MHD to EM waves at plasma discontinuity. I., 17: 11850
**KAHANA, S.**, Positron annihilation in metals, 17: 11539
**KAHN, P. B.**, Polynomials encountered in distribution function of spacings, 17: 11063 (BNL-757)
**KALBORYANU, A.**, Polarization of neutrons scattered on C-12, 17: 11741
**KALCKAR, J.**, Analytic properties of S matrix in perturbation theory, 17: 11483 (NP-12436)
**KALOS, M. H.**, Description of SORTIE I code, 17: 11591 (NP-12370)
**KAMINKER, D. M.**, Regenerative deflector theory to phasotron, 17: 11772 (BNL-767(p.134-44))
**KAMINSKY, Manfred**, Pulsed-molecular-beam mass spectrometer, 17: 10910 (TID-16209)
**KAMMERER, O. F.**, Observation of $Li^7(n,\alpha)H^3$ reaction, 17: 11615 (BNL-6082)
**KAMMURI, Tetsuo**, Multinucleon transfer reactions, 17: 11737
**KAMPER, R. A.**, Superconducting Pb–Bi a-c loss, 17: 11372
**KANGAS, G. J.**, Rod burnout heat flux tests for Pathfinder, 17: 11977 (ACNP-62028)
**KANNELAUD, J.**, Final rpt. on energy transfer in plasma, 17: 11836 (RADC-TDR-62-186)

**KANTELE, J.**, Isomeric state in Yb-176, 17: 11690
**KANTZ, A. D.**, Average neutron energy of reactor spectra, 17: 11594 (SCTM-205-62(53))
**KANUNNIKOV, V. N.**, Symmetrical ring phasotron, 17: 11776 (BNL-767 (p.181-97))
**KAPLAN, B. Yu.**, Determination of Eu in rare earth oxides, 17: 10572
**KAPLYANSKII, A. A.**, Piezospectroscopic effect in LiF, 17: 11360
**KARADZKEV, K. V.**, Polarization of charged particles, 17: 11815
**KARAYANNIS, Nicholas**, Irradiation syndrome controlled, 17: 10489
**KARAYANNIS, Nicholas**, Treatment of radiation esophagitis, 17: 10269
**KARMEN, Arthur**, Flow-through scintillation counting of C-14 and H-3, 17: 11027
**KARPFEL, Z.**, Damage by small doses of x rays, 17: 10411
**KARPOV, V. L.**, Resistance to irradiation of silicate-filled rubber vulcanizates, 17: 11286
**KARRAS, H.**, Coloring of synthetic $CaF_2$ crystals, 17: 10640
**KARULE, E.**, Ionization of H atom close to threshold, 17: 10707
**KASHCHEEV, V.**, Energy distribution of inelastically scattered neutrons. II., 17: 11510
**KASHCHEEV, V.**, Magnetic scattering of neutrons from crystals, 17: 11511
**KASTNER, Jacob**, Construction of muscle-equivalent environmental radiation meter, 17: 11011 (TID-17824)
**KASTRUP, H. A.**, Conformal transformations of space and time, 17: 11345
**KATSMA, Kenneth R.**, Boiling reactor noise, 17: 12008
**KATTCHEE, N.**, HECTIC-II, IBM-7090 FORTRAN program for heat transfer analysis, 17: 10795 (IDO-28595)
**KAUFMAN, Raymond H.**, Irradiation changes in vaginal cytology, 17: 10372
**KAUFMAN, Sheldon**, Charge distributions in interaction of 2.9-Bev protons with heavy elements, 17: 11727
**KAWAGUCHI, Masaaki**, Hypothesis of isotopic spin independence, 17: 11561
**KAWAI, Takao**, Radiation effects on polyethylene, 17: 10708
**KAWARABAYASHI, Ken**, Electromagnetic structure of the nucleon, 17: 11559
**KAWASAKI, Kyozi**, Ultrasonic attenuation in liquid He, 17: 11415
**KAY, R. B.**, Polarization of optical radiation by electron impact on He, 17: 11396
**KAYE, D. A.**, High-capacity mixer-settlers. I., 17: 10786
**KAZAHSKII, G. S.**, Interaction time between beam and target, 17: 11813
**KAZANTSEV, A. P.**, Thermoelectron emission of $HfB_2$, HfC, $HfO_2$, VC and $(UC)_1$ $(ZrC)_4$, 17: 11436
**KAZANTSEV, E. I.**, Elution of U(VI) ions from sulfocation columns, 17: 10660
**KAZARINOV, Yu. M.**, Extrapolation of experimentally determined relationships, 17: 11472 (JINR-P-1046)
**KEATON, P. W.**, Nuclear polarization in $B^{11}(d,p)B^{11}$, 17: 11637 (TID-17720(p.15-37))
**KEENE, A. R.**, Emergency planning for radiation accident, 17: 10855 (HW-SA-2609)
**KEIL, Eberhard**, X-ray bremsstrahlung in a betatron, 17: 11821
**KELLER, Donald L.**, High-temperature irradiation test of $UO_2$ fuels, 17: 11254 (BMI-1608)
**KELLY, Elmer L.**, Description of Berkeley 88-inch cyclotron, 17: 11808 (UCRL-10081)
**KELLY, F. J.**, Non-aqueous conductance data, 17: 10504 (NYO-9696)
**KELLY, W. H.**, Decay of Ba-131m, 17: 11713
**KELSCH, J. J.**, Observation of $Li^6(n,\alpha)H^3$ reaction, 17: 11615 (BNL-6082)
**KENDON, M. H.**, Control of steam-cooled reactor, 17: 10985
**KENNA, B. T.**, Determination of Cr, Co, Fe, and Ni in alloys, 17: 10539 (TID-16296)
**KENNY, P.**, Detection of bone metastases, 17: 10344
**KERN, Walter**, Radiation protection with butazolidine metabolite I Tanderil. I., 17: 10472
**KERNAN, W.**, Rapid beam ejector at Cosmotron, 17: 11785 (BNL-6678)
**KERR, Frederick W. L.**, Localization of brain lesions with $I^{131}$-labeled polyvinylpyrrolidone, 17: 10287
**KERR, R. J.**, Neutron production from D plasma, 17: 11866
**KERVINEN, J. A.**, Prog. rpt. on two-phase pressure losses, 8-11/62, 17: 10792 (GEAP-4148)
**KETOLA, Sue B.**, Influence of chemical agents on irradiated enzyme, 17: 10480 (NP-12251(p.22-33))
**KETOLA, Susan B.**, Radiation effects on thiophosphate-oxidizing enzyme system, 17: 10478 (NP-12251(p.1-11))
**KHACHATURYAN, M. N.**, Application of sparks in scintillation techniques, 17: 11037
**KHANDEL, Petru**, Low-frequency noise in semiconductors, 17: 10936
**KHANKINA, S. I.**, Energy losses of charged particles above plasma in vacuum, 17: 11886
**KHANNA, K. M.**, Phase transition in atomic nucleus, 17: 11735
**KHARCHEVNIKOV, Yu. M.**, Elution of U(VI) ions from sulfocation columns, 17: 10660
**KHARE, S. P.**, Secondary electron emission by $H^+$, $H^0$, $He^+$, and $He^0$ bombardments, 17: 11397
**KHIMICH, I. V.**, Consequences of theory of quantized field of probability amplitude, 17: 11425
**KHIMICH (KHIMITCH), I. V.**, Quantized probability-amplitude field theory, 17: 11519
**KHLOPYLYANKINA, M. S.**, Resistance to irradiation of silicate-filled rubber vulcanizates, 17: 11286
**KHOE, Tat K.**, Effect of dissociation on negative H ions in cyclotrons, 17: 11799 (TID-17617)
**KHOLMOVSKII (KHOLMOVSKIJ), Yu. (J.) A.**, Acceleration and extraction of ions in cyclotron, 17: 11778 (BNL-767(p.254-77))
**KHOMUTOV, N. E.**, Thermodynamic electronic and electrochemical properties of metals. I., 17: 10658
**KHORASANOV, G. L.**, Diffusion of plasma in magnetic field, 17: 11881
**KHRASHKO, P.**, Ionization chamber for fast neutrons, 17: 11035
**KHRISTOV, V.**, Self-shielding coefficient for Au foils, 17: 11609
**KHRUSTALEV, O. A.**, Infrared singularities and Regge trajectories in electrodynamics, 17: 11470 (JINR-E-1116)
**KIBLER, G. M.**, Prog. rpt. on refractories, 10–12/62, 17: 11191 (NP-12483)
**KICHAEVA, G. S.**, Parallel work of controlled spark gaps, 17: 11048
**KIELY, Joseph M.**, Anemia of leukemia, 17: 10341
**KIENLE, P.**, Decay of Cl-38 isomers, 17: 11747
**KIM, H. J.**, Neutron production by deuteron bombardment of B-11, 17: 11693
**KIM, Y. S.**, High-energy photoprotons from light nuclei, 17: 11704
**KIM, Young S.**, Quasi-deuteron model and distribution of nucleons in C-12, 17: 11695
**KIM, Young Song**, Radiating microspheres in treatment of malignancy, 17: 10288
**KIMBALL, R. F.**, Radiation effects on *Paramecium aurelia* growth, 17: 10408
**KIMELDORF, Donald J.**, Tumors of pancreas in irradiated and nonirradiated rat, 17: 10432
**KINELL, Per-Olof**, Radioactive wastes, 17: 12054
**KING, D.**, Prog. rpt. on radiation effects on pressure vessel steels, 7–9/62, 17: 11188 (EURAEC-485)
**KING, E. Richard**, Iodine-132 in study of thyroid function, 17: 10342
**KING, H. W.**, Lattice parameters in tetragonal metals and alloys, 17: 11330 (TID-16045)
**KINOSHITA, T.**, Fermion Regge poles, 17: 11466 (CERN-62-33)
**KIRBY, L. J.**, Radiological chemistry, 17: 10850 (HW-73337(p.77-157))
**KIRBY, Robert**, Polarography of Nb–EDTA complexes, 17: 10544
**KIRICHENKO, G. S.**, Oscillation of ions near potential minimum, 17: 11441
**KISELEVA, E. D.**, Radiation stability of ion exchanger resins, 17: 10719
**KISER, Robert W.**, Ionization and dissociation in $PCl_3$ and $P_2Cl_4$, 17: 10630
**KISS, Istvan**, Radioisotopes in food research, 17: 10882
**KISSLINGER, Leonard S.**, Particle model of scattering from collective states of nuclei, 17: 11699
**KITAO, Kazuo**, Coulomb interaction in plasma, 17: 11867
**KITAO, Kazuo**, Coulomb interaction in plasma, 17: 11869
**KJELLGREN, Olle**, Radiation dose and radiation reaction in uterine carcinoma, 17: 10259
**KLEIN, Alan F.**, Results using optical interferometry for plasma diagnostics, 17: 11853
**KLEIN, D.**, Effective U-238 resonance capture integrals, 17: 11667
**KLEIN, D.**, Equivalence relations for effective resonance integrals, 17: 11668
**KLEIN, D. T.**, Absence of interaction in mutation induction, 17: 10455
**KLEIN, R. M.**, Absence of interaction in mutation induction, 17: 10455
**KLEINPOPPEN, H.**, Electron-H atom collisions, 17: 11366
**KLEMENT, Robert**, Separation of U from trivalent Fe, 17: 10752 (GAT-Z-5035)
**KLEMM, A.**, Isothermal diffusion in electrolytes, 17: 10648

**KLEMM, A.**, Mobility of Tl isotopes in molten TlCl, 17: 10647
**KLEPPA, O. J.**, Solution of transition elements in liquid Al, 17: 10577 (ANL-FGF-292)
**KLETT, C.**, Ion mobility and electron accumulation in N, 17: 11047
**KLINE, D. E.**, Energy deposition in polymers by radiation, 17: 11280
**KLOSE, G.**, Exchange integrals between functions of K or L and O shells, 17: 11344
**KLOTZ, Paul**, Solvent extraction of Th by TTA, 17: 10727 (BNL-6099)
**KLYUCHAREV, A. P.**, Hafnium and Ge foils for nuclear studies, 17: 11178
**KLYUCHAREV, A. P.**, Proton scattering on Mg-24 at 6.9 Mev, 17: 11743
**KLYUCHAREV, A. P.**, Scattering of 6.9-Mev protons by Cr and Zn, 17: 11656
**KNOELL, H.**, Crystal solidification curves of Al and Cu, 17: 11233
**KNORR, T. G.**, Radiation effects in reactor ceramics, 17: 11125
**KOCH, R.**, Central nervous system stimulants in irradiated animal, 17: 10263
**KOCH, W.**, Radiation stability of ion exchangers, 17: 11276
**KOCHETKOV, N. K.**, Mass-spectroscopic study of carbohydrates, 17: 10557
**KODOCHIGOV, P. N.**, Ionizing radiation dosimetry, 17: 10879
**KOFMAN, Sydney**, Strontium-85 in evaluation of bone metastases, 17: 10279
**KOLAR, V.**, Damage by small doses of x rays, 17: 10411
**KOLGANOVA, E. D.**, Absorption of mesons in emulsion nuclei, 17: 11679
**KOLL, Helmut**, Production of thin plates of $UO_2$, 17: 11167 (NP-12228)
**KOLLER, E. L.**, Radiative $\tau^+$ decay, 17: 11536
**KOLOMENSKII, A. A.**, Incident modulation of parameters in cycle accelerators, 17: 11822
**KOLOMENSKII (KOLOMENSKIJ), A. A.**, Symmetrical ring phasotron, 17: 11776 (BNL-767(p.181-97))
**KOLOT, V. Ya.**, Thermionic emission of metals in different gases, 17: 11435
**KOLOTI, V. V.**, Neutron monochromator consisting of disks, 17: 10937
**KOLOTI, V. V.**, Pulse form and transmission function of two-rotor neutron chopper. I., 17: 10938
**KOMAR, Arthur**, Positive-definite energy density and global consequences for general relativity, 17: 11918
**KOMIN, A. V.**, Diffusion of plasma in magnetic field, 17: 11881
**KOMLEV, L. V.**, Problems in radiogeology, 17: 10841
**KONDO, Jun**, Hall effect in Gd metals, 17: 11417
**KONDRASHOV, N. G.**, Temperature field in cylindrical fuel element, 17: 10810
**KONSTANTINOV, B. P.**, Diffusion of charged particles in dense plasma, 17: 11880
**KONZAK, C. F.**, Relation of embryo structure to effects of x rays in barley, 17: 10453
**KOO, F. K. S.**, Effect produced by x rays and thermal neutrons in diploid and hexaploid species of *Avena*, 17: 10457
**KOPP, P. M.**, Radiation protection in aqueous polymer solutions, 17: 10690
**KOPYLOV, G. I.**, Statistical background of resonant states, 17: 11474 (JINR-P-1079)
**KOROBOCHKO, Yu. S.**, Cylinder iron-free betatron with axial magnetic focusing, 17: 11823
**KOROSTYSHEVSKII, I. Z.**, Automatic scanning of mass spectrometer magnetic field, 17: 10933
**KORPAK, Wincenty**, Extraction of mineral acids and U salts. I., 17: 10767
**KOSALY, G.**, Quasi-classical approximation in neutron scattering, 17: 11606
**KOSHKAREV, D. G.**, Design considerations for proton synchrotron, 17: 11767 (BNL-767(p.75-83))
**KOSHKAREV, D. G.**, Experiment with colliding beams without storage, 17: 11775 (BNL-767(p.172-6))
**KOSOUROV, G. I.**, Efficiency of radiation counter submerged in active zone, 17: 11040
**KOSOUROV, G. I.**, Strontium-90 in Atlantic surface waters, 17: 10835
**KOSSEL, F.**, Pendulum multiplication of secondary electrons, 17: 11576
**KOTHARE, V. V.**, CIR team solved corrosion, deposition problems, 17: 11136
**KOTTWITZ, D. A.**, Scattering law for light water, 17: 11589 (HW-75526)
**KOULKES-PUJO, Anne-Marie**, Effects of $\gamma$ rays on Au chloride solutions, 17: 10696
**KOVAL'CHENKO, M. S.**, Sintering of powders of refractory compounds, 17: 11170 (AEC-tr-5604)
**KOVALENKO, A. V.**, Leukocyte motility in Ra therapy, 17: 10445
**KOVAL'SKII, N. G.**, Loss of plasma through magnetic aperture of traps, 17: 11841 (AEC-tr-5620)
**KOVI, Jozsef**, Effect of Y-90 on pituitary, 17: 10451
**KOWALSKI, S.**, Polarization of neutrons from photodisintegration of D, 17: 11551
**KOZINETS, G. I.**, Myeloid cells in acute radiation sickness, 17: 10495
**KOZINETS, O. I.**, Linear ion bunching device, 17: 11814
**KRACHINO, T. V.**, Thermoelectron emission of $HfB_2$, HfC, $HfO_2$, VC, and $(UC)_1$ $(ZrC)_4$, 17: 11436
**KRAEMER, M.**, Preparing labeled drugs by neutron activation, 17: 10683
**KRAJEWSKI, Bohdan**, Temperature field in pebble bed gas cooled reactor, 17: 11974
**KRALL, Nicholas A.**, Low-frequency stability of nonuniform plasmas, 17: 11847
**KRAMER, W. C.**, Vacuum brazing of superheater fuel plates, 17: 11078 (ANL-FGF-329)
**KRASKA, I. R.**, Film copying technique for improving radiographic contrast, 17: 10891 (ANL-FGF-339)
**KRASKA, I. R.**, Scintillator-polaroid film camera for neutron image detection, 17: 10999 (ANL-FGF-340)
**KRASNIK, W.**, Phosphorus-32 treatment of erythremia, 17: 10286
**KRAUSE, Ingrid Y.**, g Factor of first excited state in V-51, 17: 11700
**KRAVCHENKO, L. Kh.**, Precipitation of certain elements from fused $NH_4NO_3$, 17: 10621
**KRAWCZYNSKI, S.**, Applicability of dibutyl ether for preparation of irradiated fuel by extraction, 17: 10755
**KRAYBILL, Herman F.**, Rat feeding studies with $\gamma$-irradiated foods, 17: 10350
**KREBS, K.**, Pendulum multiplication of secondary electrons, 17: 11576
**KREGAR, M.**, Alpha spectrum from $(\gamma,\alpha)$ on V-51, 17: 11678
**KRETSCHMER, Roberto R.**, Rejection of skin homografts in rabbits. II., 17: 10425
**KRIIGLOV, S. P.**, Energy losses of bremsstrahlung beam, 17: 11585
**KRISHNAN, K. S.**, Anomalies in thermal expansion of dilute solid solutions, 17: 11238
**KRISTOFFERSSON, Harry**, Distribution of Pu in mice, 17: 10260
**KRIVSKII, I. Yu.**, Consequences of theory of quantized field of probability amplitude, 17: 11425
**KRIVSKII, I. Yu.**, Quantized probability-amplitude field theory, 17: 11519
**KROLL, H.**, Fuel element fabrication of $UO_2$ powders, 17: 11149 (CEND-153(Vol.I)(p.125-35))
**KRONE, R. W.**, Reaction $C^{13}(p,\gamma)N^{14}$ and states in N-14, 17: 11714
**KRONMUELLER, H.**, Depolarization and scattering of neutrons by ferromagnetic crystals, 17: 11610
**KRTIL, J.**, Extraction of Cs tetraphenyl borate, 17: 10757
**KRUEGER, H.**, Electron-H atom collisions, 17: 11366
**KRUEGER, H. G.**, Photoelectric Leitz spectrometer, 17: 10953
**KRUH, R. F.**, Structure of liquid Hg, 17: 11232
**KRUMBIEGEL, P.**, Isotopes in chemistry of elastomers, 17: 10691
**KRUPNOVA, V. N.**, Radiation stability of ion exchanger resins, 17: 10719
**KRYNETSKII, I. B.**, Millimeter radiospectroscope, 17: 10931
**KUBLI, F.**, Shock and anuria after irradiation of uterine myomatosus, 17: 10496
**KUBOTA, Y.**, Magnetic characteristics of hydrogenated Ho, 17: 10599 (TID-15935)
**KUBOTA, Y.**, Magnetic characteristics of Gd, Tb and Y hydrides, 17: 11329 (TID-15934)
**KUCA, L.**, Plutonium(IV) extraction with aliphatic ketones, 17: 10758
**KUCHEROV, R. A.**, Kinetic theory of diode filled with plasma, 17: 11437
**KUCKES, Arthur F.**, Evaluation of Kadomtsev's theory of plasma turbulence, 17: 11833 (MATT-114)
**KUEHNERT, C. C.**, Changes induced in tomato by irradiation, 17: 10452
**KUENLEN, Hermann**, Dose distribution in use of oblique tube, 17: 10878
**KUHN, W.**, Measurement of Fe-59 and Cr-51 activities at body surface of patients, 17: 10271
**KULSRUD, Russell M.**, Stability of stellarator, 17: 11788 (MATT-119)
**KUMPF, G.**, Transfer reactions in Th irradiation by Ne-22, 17: 11473 (JINR-P-1071)
**KUNKEL, Wulf B.**, Electron-energy distribution in H with magnetic fields, 17: 11839 (UCRL-10366)
**KUNZE-MUEHL, E.**, Radiation-induced chromosome dislocations in

*Drosophila subobscura*, 17: 10403
**KURIMURA, Yoshimi**, Gamma-induced oxidation yield of Fe(II), 17: 10569
**KURNAKOV, N. N.**, Creep in Ti–Sn and Ti–Zr–Sn alloys, 17: 11211
**KURSANOV, [Yu.] (U.) V.**, Ion sources with plasma contraction by inhomogeneous field, 17: 11777 (BNL-767(p.224-53))
**KUSHTAN, V. I.**, Principle of invariance under inversion, 17: 11520
**KUTSCHKE, K. O.**, Separation of H isotopes on activated alumina, 17: 11057
**KUZMIN, A. A.**, Control system for beam in synchrotron, 17: 11764 (BNL-767(p.48-63))
**KUZMIN, A. A.**, Electronic systems for proton synchrotron, 17: 11763 (BNL-767(p.32-47))
**KUZMIN, V. F.**, Electronic systems for proton synchrotron, 17: 11763 (BNL-767(p.32-47))
**KUZ'MINA, N. I.**, Automatic closed orbit control, 17: 11811 (NP-tr-932)
**KUZNETSOVA, L. V.**, Peripheral vessels in persons working on cyclotron, 17: 10444
**KVITTNER, P.**, Ionization chamber for fast neutrons, 17: 11035
**KYRS, M.**, Extraction of Cs tetraphenyl borate, 17: 10757
**KYRS, M.**, Extraction of Cs compounds with nitrobenzene, 17: 10759

# L

**LADU, Mario**, Radiation response of mouse embryonic lung, 17: 10420
**LA FAVE, James W.**, Radiating microspheres in treatment of malignancy, 17: 10288
**LALLY, F. J.**, Tungsten emitters for ion propulsion systems, 17: 11080 (ASD-TDR-62-756)
**LAM, D. J.**, Binary systems of Tc-99 with transition elements, 17: 11220
**LAMB, James**, Determining Ra-226 in soil samples, 17: 10531 (ANL-6637 (p.97-9))
**LAMBERT, R. H.**, Pressure shifts of hfs of atomic N, 17: 11387
**LAMERTON, Leonard F.**, Cell population studies on intestine of irradiated rats, 17: 10355 (BNL-6113)
**LANE, R. K.**, Resonance absorption in materials with grain structure, 17: 11604
**LANE, R. O.**, Energy-dependent multiple scattering of neutrons, 17: 11595 (TID-15571)
**LANGER, L. M.**, Shape of $0^+ \rightarrow 0^+$ positron spectrum in Ga-66, 17: 11724
**LANGHAM, W. H.**, Plutonium in man, 17: 10338
**LANNING, W. D.**, Application of spherical harmonics technique to problems in $\gamma$ transport, 17: 11502 (WAPD-T-1458)
**LAPIDUS, L. I.**, Interpretation of high-energy neutrino experiments, 17: 11471 (JINR-E-1120)
**LAPINSKI, N. P.**, Film copying technique for improving radiographic contrast, 17: 10891 (ANL-FGF-339)
**LARI, Robert J.**, Magnetic measurements of bending magnet BM-102, 17: 11804 (TID-17693)
**LARSON, A. C.**, Indirect relativistic effect on 5f electrons in U, 17: 11395
**LARSON, W. L.**, Prog. rpt. on power reactors, 8/62, 17: 11095 (NMI-7254)
**LARSON, W. L.**, Prog. rpt. on power reactors, 10/62, 17: 11096 (NMI-7256)
**LARSON, W. L.**, Prog. rpt. on power reactor program, 11/62, 17: 11097 (NMI-7257)
**LATIMORE, David S.**, SCRAMBLE—for simulation of peripheral equipment on IBM 1401, 17: 11074 (XDC-61-5-2)
**LATSKO, E. M.**, Magnetic areas in systems with helical magnetic field, 17: 11879
**LATTA, Harrison**, Renal tubular fine structure during U injury, 17: 10265
**LAUGHLIN, J. S.**, Detection of bone metastases, 17: 10344
**LA VELLE, E. B.**, Weldability of metals, 17: 11166 (HW-SA-2527)
**LAVERICK, C.**, Experiments with superconducting wire and solenoids, 17: 11335 (TID-17827)
**LAW, M. E.**, Decay of Pm-151, 17: 11652
**LAWERGREN, B. T.**, Level of Al-27 at 2.21 Mev, 17: 11686
**LAWERGREN, B. T.**, Resonance of $Mg^{24}(p,\gamma)$ reaction, 17: 11680
**LAWLESS, Francis**, Separation of actinides with nitric acid–methanol and EDTA, 17: 10771
**LAWRENCE, J. H. P.**, Plutonium in man, 17: 10338
**LAWSON, Joan**, Positron elastic scattering by atomic H, 17: 11328 (TID-15769)
**LBOV, A. A.**, Determination of Au by activation, 17: 10573
**LEACH, C. M.**, Radiation effects on wheat, 17: 10374
**LEARY, J. A.**, Reactor irradiation of U-impregnated graphite, 17: 11261 (LANS-2814)
**LEBEDEV, A. N.**, Incident modulation of parameters in cycle accelerators, 17: 11822
**LEBEDEV, N. N.**, Diffraction of EM waves on wedge of finite conductivity, 17: 11434
**LEBEDEV-KRASIN, Y[u]. M.**, Electronic systems for proton synchrotron, 17: 11763 (BNL-767(p.32-47))
**LE BLANC, J. M.**, Lithium-6 and $Li^7(n,2n)$ cross sections, 17: 11722
**LEBLANC, J. M.**, Thermal expansion of $UO_2$, $PuO_2$, and $UO_2$–$PuO_2$, 17: 11203 (EURAEC-434)
**LEDOUX, L.**, Metabolism of barley seedlings. III. Effect of x rays, 17: 10456
**LEFORT, Marc**, Emission of $\alpha$ particles in spallation reactions, 17: 11663
**LEGAR, F.**, Extrapolation of experimentally determined relationships, 17: 11472 (JINR-P-1046)
**LEGLER, Werner**, Modified Wien filter as electron monochromator, 17: 10939
**LEGRAND, E.**, Characteristics of neutron beams from BR2, 17: 12022 (BLG-147)
**LEHMAN, Richard L.**, Neutron dosimetry by nuclear track emulsion, 17: 10868 (UCRL-9967(Rev.))
**LEHMANN, Pierre**, Elastic electron-deuteron scattering and neutron EM structure, 17: 11505
**LEHMANN, Pierre**, Elastic electron-proton scattering, 17: 11506
**LEHMANN, R.**, Coloring of synthetic $CaF_2$ crystals, 17: 10640
**LEIBFRIED, G.**, Averages of primary recoil distributions, 17: 11750
**LEIMDOERFER, M.**, Backscattering of $\gamma$ radiation from plane concrete walls, 17: 11895 (AE-92)
**LEIMDOERFER, M.**, Backscattering of $\gamma$ radiation from spherical concrete walls, 17: 11896 (AE-93)
**LEIMDOERFER, M.**, Cross sections for neutron inelastic scattering and (n,2n) processes, 17: 11587 (AE-88)
**LEIMDOERFER, Martin**, Multiple reflection of $\gamma$ radiation in spherical concrete wall room, 17: 11897 (AE-94)
**LEINER, George C.**, Radiopulmonogram, 17: 10280
**LEIZERAHA, S.**, Malignancy of tubercular lupus after x irradiation, 17: 10441
**LEMBRA, Yu. Yu. (J. J.)**, Regenerative deflector theory to phasotron, 17: 11772 (BNL-767(p.134-44))
**LEMMER, Richard H.**, Deuteron stripping in Coulomb field, 17: 11630 (TID-15924)
**LENGEMANN, F. W.**, Prog. rpt. on fission product metabolism, 4/62–1/63, 17: 10310 (TID-17789)
**LENGEMANN, F. W.**, Yttrium-91 study of food movement in small intestine, 17: 10281
**LENGEROVA, Alena**, Graft-vs.-graft immunological tolerance in radiation chimeras, 17: 10270
**LEONARD, B. R., Jr.**, Scattering law for light water, 17: 11589 (HW-75526)
**LEONARD, J. H.**, Physics tests on PWR-1 Seed 2, 17: 11991 (WAPD-PWR-TE-81)
**LEONT'EV, G. A.**, Iodide refining of Nb, 17: 10635
**LEONTEV, N. I.**, Penetration of magnetic field into plasma, 17: 11885
**LE PIPEC, Clement**, Resonant interaction of neutrons with U-238, 17: 11655
**LEVI, C.**, Ericson fluctuations in $Al^{27}(d,\alpha)Mg^{25}$, 17: 11675
**LEVI, Josif**, Selection of type of atomic power plant, 17: 11976
**LEVICH, Veniamin G.**, Physicochemical hydrodynamics, 17: 10813
**LEVIN, Jack**, Dental occupational exposure to ionizing radiation, 17: 10872
**LEVIN, S. A.**, Separation of isotopes by gaseous diffusion, 17: 11052 (TID-15348)
**LEVY, Paul W.**, Vacancies produced in NaCl by fast reactor neutrons, 17: 11377
**LEWIS, Gerald P.**, Oxidation of H and D on rotating disk electrode, 17: 10628
**LIBMAN, G.**, Hydrogen–D bubble chamber in magnetic field, 17: 10930
**LIEBMANN, B.**, Fuel element fabrication of $UO_2$ powders, 17: 11149 (CEND-153(Vol.I)(p.125-35))
**LIETZKE, M. P.**, CASPER: program for plotting and scaling data, 17: 11066 (ORNL-3394)
**LIIMATAINEN, Robert C.**, Vapor-liquid equilibrium in $BrF_3$–$UF_4$ system,

17: 10595 (TID-15770)
**LIM, Y. K.**, Meson production in interactions of protons with emulsion, 17: 11611 (AD-277387)
**LINDBLAD, R.**, Aluminum alloys as cladding materials, 17: 11120
**LINDEKEN, C. L.**, Plutonium alpha air monitor, 17: 11012 (UCRL-6692)
**LINDEKEN, C. L.**, Portable DOP tester for inspection of high-efficiency filters, 17: 10922
**LINDENBAUM, Arthur**, Removal of Pu from blood, 17: 10327
**LINDENFELD, P.**, Thermal conductivity of superconductors, 17: 11406
**LINDER, Bruno**, Indium-117 and In-117m in $Sn^{120}(p,\alpha)$ reaction, 17: 11696
**LINDNER, Albrecht**, Statistical theory of nuclear reactions, 17: 11754
**LINDQUIST, Arthur W.**, Treatment of mosquito larvae with P-32, 17: 10423
**LINEVSKY, M. J.**, Prog. rpt. on refractories, 10–12/62, 17: 11191 (NP-12483)
**LINGAFELTER, J. W.**, Performance of compacted powder $UO_2$ fuel rods, 17: 11156 (CEND-153(Vol.II)(p.67-76))
**LINHART, J. G.**, Z pinch and thermal energy concentration, 17: 11846
**LINIGER, Werner**, Critical fields of superconducting films, 17: 11399
**LIPAS, P. O.**, Perturbation corrections in deformed nuclei, 17: 11665
**LIPPINCOTT, S. W.**, Kinetics of Ca-47 and Sr-85 in man, 17: 10293 (BNL-6108)
**LIPPMANN, M.**, Prog. rpt. on stmtospheric monitoring, 4-7/62, 17: 10902 (NYO-9676)
**LIPPMANN, M.**, Urine U excretion data, 17: 10305 (HASL-120)
**LITOVCHENKO, S. G.**, Position-electron annihilation in alloys, 17: 11275
**LITTMAN, Armand**, Intragastric irradiation with $Ru–Rh^{106}$, 17: 10367 (TID-17727)
**LITTMAN, Margaret S.**, Intragastric irradiation with $Ru–Rh^{106}$, 17: 10367 (TID-17727)
**LITVAK, D. M.**, Millimeter radiospectroscope, 17: 10931
**LIU, F. F.**, High-energy photoprotons from light nuclei, 17: 11704
**LIU, Lu Sun**, Regge trajectory in field theory, 17: 11919
**LJUNGBERG, Gregory**, Conference on instruments and measurements, 17: 10941
**LJUNGBERG, Gregory**, Conference on instruments and measurements, 17: 10956
**LLACER, Jorge**, Low frequency amplifier IH-130-1, 17: 10892 (BNL-6437)
**LLOYD, L. J.**, Determination of branching ratio $\Gamma(\eta \to \pi^+\pi^-\gamma)/\Gamma(\eta \to \pi^+\pi^-\pi^0)$, 17: 11552
**LLOYD, R. C.**, Critical mass experiments with $Pu(NO_3)_4$, 17: 11459 (HW-SA-2432(Rev.))
**LOBIKOV, E. A.**, Energy distributions in strong current toroidal discharge, 17: 11884
**LOCK, Frank R.**, Complications of radiation therapy for cervical carcinoma, 17: 10449
**LOCKWOOD, P. A.**, Radioactive fuel-bearing glasses, 17: 11102 (NYO-9735)
**LOEFFLER, F. J.**, High-energy photoprotons from light nuclei, 17: 11704
**LOFING, D. R.**, Activity analysis GAIL III-A fuel element, 17: 11944 (GAMD-3378)
**LOGUNOV, A. A.**, Regge poles and perturbation theory. II., 17: 11905 (JINR-E-1095)
**LOGUNOV, V. N.**, Effect of injector focusing on $\gamma$ intensity in betatron, 17: 11816
**LOGVINOV, V. V.**, Penetration of magnetic field into plasma, 17: 11885
**LOHFF, Juergen**, Energy losses in scattering of electrons on Al, 17: 11757
**LOMSADZE, Yu. M.**, Consequences of theory of quantized field of probability amplitude, 17: 11425
**LOMSADZE, Yu. M.**, Principle of invariance under inversion, 17: 11520
**LOMSADZE, Yu. M.**, Quantized probability-amplitude field theory, 17: 11519
**LONBERG-HOLM, K. K.**, Measuring radioactivity on two-dimensional paper chromatograms, 17: 10543
**LONSDALE, Harold K.**, Boron carbide–graphite nuclear control-rod material, 17: 11085 (GA-3064)
**LOOMIS, B. A.**, Swelling of U, 17: 11265 (TID-15774)
**LOOSEMORE, W. R.**, Fission chamber detectors, 17: 10987
**LOPATIN, I. V.**, Energy losses of bremsstrahlung beam, 17: 11585
**LOSKIEWICZ, J.**, Energetic particle interactions with atomic nuclei at mountain altitudes, 17: 11454
**LOSKIEWICZ, J.**, Interactions of $\pi^-$ mesons with Xe, 17: 11673
**LOVE, D. L.**, System for rapid handling of irradiated solution, 17: 10784 (USNRDL-TR-601)
**LOVE, H. M.**, Diffusion of Li in W, 17: 11206
**LOVEJOY, C. A.**, Anomalous quadrupole coupling in Eu ethylsulfate, 17: 11647 (UCRL-10202)
**LOW, W.**, Fluorescence spectra of transition elements, 17: 11368
**LOWELL, Alan F.**, Vertical integration in nuclear fuel industry, 17: 10724
**LOZIER, Donald E.**, High-temperature irradiation test of $UO_2$ fuels, 17: 11254 (BMI-1608)
**LUBKIN, Elihu**, Theory of nucleon-nucleon scattering in strip approximation, 17: 11498 (UCRL-10028)
**LUCAS, C. B.**, Polarization of electron impact radiation in He, 17: 11409
**LUCAS, H. F., Jr.**, Translocation of Th daughters to bone, 17: 10351
**LUCAS-TOOTH, H. J.**, X-ray fluorescent analysis, 17: 10949
**LUND, J. A.**, Reaction of Li with $H_2O$ vapor, 17: 10622
**LUNDELL, B.**, Fuel-channel temperature scanning equipment, 17: 10992
**LUNDIN, C. E.**, Intermediate phases of intra-rare-earth binary systems, 17: 11186 (DRI-2080)
**LUNDY, T. S.**, Separating grain-boundary and lattice diffusion effects in polycrystalline materials, 17: 11236
**LUNGU, S. N.**, Equilibrium diagram of $UO_3$–$SiO_2$, 17: 10641
**LURIE, H.**, Critical heat flux of polyphenyl coolants, 17: 10800 (NAA-SR-7954)
**LUSTMAN, B.**, Effects of burnup on oxide ceramic fuels, 17: 11270 (WAPD-T-1455)
**LUTSIK, V. A.**, Scattering of 6.9-Mev protons by Cr and Zn, 17: 11656
**LUXTON, R. W.**, Radiation nephritis: long-term study, 17: 10440
**LYAPIDEVSKII, V. K.**, Determining air pollution by Rn daughter products, 17: 10560
**LYASS, F. M.**, Radiometry of granules of activated Y, 17: 11029
**LYNCH, Gerald R.**, Four-pion resonance and decay modes of $\rho$ and $\omega$ mesons, 17: 11499 (UCRL-10089(Rev.))
**LYNTON, E. A.**, Thermal conductivity of superconductors, 17: 11406
**LYON, T. F.**, Prog. rpt. on refractories, 10–12/62, 17: 11191 (NP-12483)
**LYONS, E. Ann**, Survival time after whole-body radiation, 17: 10467
**LYUBCHENKO, V. F.**, Compressing He-3 into counters, 17: 10934
**LYUBIMOV, V. D.**, Carbon monoxide reduction of $Nb_2O_5$, 17: 10661

# M

**MACCHIAVERNA, Edmundo Guillermo**, Uranium recovery in carbonate solutions, 17: 10769
**MAC DOWELL, S. W.**, Production and spin of $K^*$ resonance, 17: 11487 (NP-12488)
**MACHERAUCH, E.**, Crystal solidification curves of Al and Cu, 17: 11233
**MACHNIG, Oskar**, Gas-cooled high-temperature reactor, 17: 11998 (AEC-tr-5484)
**MACKINTOSH, A. R.**, Scattering of conduction electrons, 17: 11367
**MAC LEAN, Lloyd D.**, Radiating microspheres in treatment of malignancy, 17: 10288
**MAC MILLAN, D. B.**, Kinetics of low source reactor startups. I., 17: 11960 (TID-16142(Pt.I))
**MAC MILLAN, D. B.**, Kinetics of low source reactor startups, 17: 11961 (TID-16142(Pt.II))
**MADANSKY, Leon**, Nuclear polarization in $B^{11}(d,p)B^{12}$, 17: 11637 (TID-17720(p.15-37))
**MADANSKY, Leon**, Production of polarized beams using metastables, 17: 11640 (TID-17720(p.79-89))
**MADANSKY, Leon**, Search for lepton pairs, 17: 11642 (TID-17720(p.98-100))
**MADDEN, Sidney C.**, Renal tubular fine structure during U injury, 17: 10265
**MAGAS, S.**, Phosphorus-32 treatment of erythremia, 17: 10286
**MAGNUSSON, A. W.**, Aluminum alloys as cladding materials, 17: 11120
**MAHAFFEY, Derek W.**, Microwave propagation through plasma in magnetic field, 17: 11862
**MAINS, Gilbert J.**, Formation of benzene in radiolysis of acetylene, 17: 10698
**MAITA, J. P.**, Specific heats of transition metal superconductors, 17: 11380
**MAKAROUNIS, O.**, Thermal diffusivity and heat capacity measurements, 17: 11200 (USNRDL-TR-599)

**MAKI, Kazumi**, Effects of impurity scattering on excitons, 17: 11412
**MAKI, Kazumi**, Strength of coupling constant and vacuum stability, 17: 11924
**MAKOVSKY, J.**, Fluorescence spectra of transition elements, 17: 11368
**MALAMOS, B.**, Prog. rpt. on radiation effects on lipid metabolism, 5–12/62, 17: 10365 (TID-17692)
**MALEK, Zdenek**, Recovery of uranyl sulfate by tri-n-octylamine, 17: 10756
**MALHOTRA, Pavan K.**, Coincidence technique for transistor decade counter, 17: 11021
**MALINOWSKI, Jerzy**, Determination of As in Zn, 17: 10563
**MALINOWSKI, Jerzy**, Spectrometric determination of trace amount of Cs in Na and K salts, 17: 10565
**MALONE, M.**, Prog. rpt. on radiation effects on pressure vessel steels, 7–9/62, 17: 11188 (EURAEC-485)
**MALUSZYNSKA, Krystyna**, Fast neutrons elastically scattered on Ca, 17: 11593 (PAN-354/I-A)
**MALY, Ya.**, Separation of Fm and Md, 17: 10735 (JINR-P-1075)
**MAMYRIN, B. A.**, Mass spectrometer with two-stage ion separation, 17: 10932
**MANARESI, P.**, $\beta$-absorption and glass transitions in polymers, 17: 11282
**MANDIL, M. A.**, Separation of Y-91 and Pm-147, 17: 10746 (TID-15792)
**MANI, G. S.**, Excited states in N-14, 17: 11623 (NP-12496)
**MANN, Evelyn B.**, BEI values of adolescents exposed to Nagasaki bomb, 17: 10371
**MANN, Karl Ernst**, Fatique tests of light metal alloys, 17: 11245
**MANNELLI, I.**, Periodic integrator, 17: 11024
**MANSARD, B.**, Prog. rpt. on forming and irradiation of UC, 4–6/62, 17: 11110 (EURAEC-387)
**MANSFIELD, R. G.**, Comparison of DBPP and DSBPP with TBP for recovery of U and Th, 17: 10738 (ORNL-3374)
**MANUS, C.**, Anomalous diffusion in a plasma, 17: 11857
**MARAMAN, W. J.**, Reactor irradiation of U-impregnated graphite, 17: 11261 (LAMS-2814)
**MARAZZI, Carlos**, Electrometric amplifier, 17: 10899 (NP-12229)
**MARCATO, Marco**, Lymph of thoracic duct in irradiated rabbits, 17: 10462
**MARCHAND, B.**, Decomposition of monazite sand, 17: 10556
**MARCHAND, J. F.**, New type of parallel cryotron, 17: 10927
**MARCHELLO, J. M.**, Theoretical investigation of agitated ion exchange beds, 17: 10763
**MARCHUK, P. M.**, Pipe-pinch stability, 17: 11882
**MARCHUKAITIS, A. S.**, Role of lipoprotein in protein synthesis, 17: 10314
**MARCOVICH, H.**, Prog. rpt. on radiation effects on genetic materials, [1962], 17: 10364 (TID-17690)
**MARCOWITZ, S. M.**, Unseparated antiproton beam for counter experiments, 17: 11803 (TID-17691)
**MARCUS, C. S.**, Yttrium-91 study of food movement in small intestine, 17: 10281
**MARCUS, Y.**, Anion exchange of metal complexes. VIII., 17: 10588 (IA-764)
**MARCUS, Y.**, Anion exchange of metal complexes. IX., 17: 10732 (IA-779)
**MARILLIER, J. C.**, Treatment of radioactive wastes, 17: 12053
**MARIN, G.**, X-ray effects on guinea pig cells, 17: 10383
**MARINELLI, L. D.**, Translocation of Th daughters to bone, 17: 10351
**MARKELS, Michael, Jr.**, Prog. rpt. on boiling heat transfer, 9/60-2/62, 17: 10801 (NYO-10345)
**MARKLEY, John F.**, Removal of Pu from blood, 17: 10327
**MARKOVSKII, L. Ya.**, Boron carbides in C reduction of rare earth mixtures with B, 17: 10662
**MARKOWITZ, Samuel S.**, Excitation function for $C^{13}(\pi^-,\pi^-n)C^{11}$ reaction, 17: 11648 (UCRL-10312)
**MARKS, S.**, Toxicity of inhaled Pu in dogs, 17: 10322
**MARTENSEN, E.**, Stability behavior of plasma torus, 17: 11872
**MARTENSON, Morten**, Isotope separation by gaseous diffusion, 17: 11060
**MARTIN, A.**, Unitarity and high-energy behavior of scattering amplitudes, 17: 11912
**MARTIN, E. C.**, Solvent extraction of Cs by dipicrylamine, 17: 10731 (HW-SA-2620)
**MARTIN, John H.**, Protons from 50 Mev to 12.5 Bev, 17: 11494 (TID-17627)
**MARTINEZ, Carlos**, Lympho-reticular cells in lasting tolerance, 17: 10289
**MARTY, C.**, Appearance of lymphoid tumors in mice, 17: 10406
**MARUMORI, Toshio**, Collective motion in even-even deformed nuclei, 17: 11732
**MARX, Rose**, Spectra of solid irradiated formaldehyde, 17: 10695
**MASOERO, A.**, Evaluation of occupational injury from radiation, 17: 10447
**MASON, G. W.**, Extraction of U(IV) by phosphates and phosphonates, 17: 10745 (TID-15773)
**MASON, G. W.**, Separation of Y-91 and Pm-147, 17: 10746 (TID-15792)
**MASSALSKI, J.**, Energetic particle interactions with atomic nuclei at mountain altitudes, 17: 11454
**MASSALSKI, T. B.**, Lattice parameters in tetragonal metals and alloys, 17: 11330 (TID-16045)
**MASSAROTTI, A.**, Phase discriminator for tuning cavity resonator, 17: 11791 (RT/EL(62)14)
**MASSEY, H. S. W.**, Positron elastic scattering by atomic H, 17: 11328 (TID-15769)
**MATHEWS, Jon**, Radial magnet alignment method, 17: 11786 (CTSL-36)
**MATOLICH, J., Jr.**, Thermal conductivity of $UO_2$, 17: 11258 (HW-69945)
**MATSKEVICH, T. L.**, Thermoelectron emission of $HfB_2$, HfC, $HfO_2$, VC and $(UC)_1(ZrC)_4$, 17: 11436
**MATSON, L. K.**, Semiconducting properties of rare earths, 17: 11296 (AD-278352)
**MATSUDA, Tosuo**, Radiation effects on $CCl_4$ solutions, 17: 10709
**MATSUMOTO, Masahiko**, EM transitions for photodisintegration of deuteron, 17: 11531
**MATSUURA, Kenya**, Damping of plasma oscillations, 17: 11870
**MATSUURA, Niro**, Gamma-induced oxidation yield of Fe(II), 17: 10569
**MATTHIAS, B. T.**, Intermediate isotope effect of Mo and $Mo_3Ir$, 17: 11375
**MATTHIAS, Eckart**, Influence of magnetic dipole electric quadrupole interaction on angular correlations, 17: 11386
**MATUMOTO, Z.**, Structure of $2^+$ states in even-even nuclei, 17: 11698
**MATYUSHENKO, N. I.**, Niobium and Zr effects on austenitic steel, 17: 11210
**MAXSON, D. R.**, Angular distributions of (n,d) reactions at 14 Mev, 17: 11716
**MAYDAN, Dalieh**, Anion exchange of metal complexes. VIII., 17: 10588 (IA-764)
**MAYDAN, Dalieh**, Anion exchange of metal complexes. IX., 17: 10732 (IA-779)
**MAYER-BOERICKE, C.**, Investigations on stone meteorites, 17: 10839
**MAYO, Thomas T., IV**, Countercurrent flow in semi-infinite gas centrifuge, 17: 11054 (UVA-279-63U)
**MAYS, C. W.**, Interlaboratory and interstandard comparisons of Sr-90, 17: 10299 (COO-226(p.66-70))
**MAYS, C. W.**, Radium studies in man soon after injection, 17: 10300 (COO-226(p.71-77))
**MAYS, Charles W.**, Alpha dose from surface and volume deposits of Pu-239, Th-228, and Ra-226, 17: 10301 (COO-226(p.78-85))
**MAYS, Charles W.**, Radium dosimetry, 17: 10302 (COO-226(p.86-94))
**MC CABE, Charles Lew**, Free energy of formation of Ce and Pr monocarbides, 17: 10644
**MC CAFFREY, Irmgarde**, Flow-through scintillation counting of C-14 and H-3, 17: 11027
**MC CARLEY, R. E.**, Preparation and properties of $MoBr_4$, 17: 10590 (IS-487)
**MC CARLEY, R. E.**, Reactions of Nb(V) halides with pyridine, 17: 10500 (IS-385)
**MC CHESNEY, Malcolm**, Shock waves and high temperatures, 17: 11424
**MC CLELLAN, R. O.**, Transfer of transuranic elements to milk, 17: 10326
**MC CLELLAND, Jean**, Plutonium in man, 17: 10338
**MC CRACKEN, G. M.**, Diffusion of Li in W, 17: 11206
**MC CRICKARD, J.**, Instrumentation in nuclear stations, 17: 10995
**MC CUBBIN, W. L.**, Radiation-induced crosslinking of polymers, 17: 11279
**MC DONALD, P. H.**, Pulsed electrostatic analyzer for ion energy determinations, 17: 11010 (TID-16311)
**MC DONALD, W. J.**, Reaction $P^{31}(\gamma,n)P^{30}$, 17: 11653
**MC FARLAND, O. K.**, Spectrophotometric determination of Co, 17: 10540 (TID-17745)
**MC INTYRE, J. A.**, Heavy-ion detection system, 17: 11008 (TID-16174)
**MC INTYRE, J. A.**, Uniformity of commercial foils, 17: 11104 (TID-16252)
**MC LAUGHLIN, Donald W.**, Neutrons embrittlement reactor vessels, 17: 11287
**MC LAUGHLIN, J. E., Jr.**, Criticality and criticality control, 17: 10528

(ANL-6637(p.43-57))
**MC MILLAN, Corey,** Analysis of fracture surfaces by electron miscroscopy, 17: 11185 (D1-82-0169)
**MC MILLAN, J. A.,** Paramagnetic resonance of photolyzed solid $H_2O_2$, 17: 10679 (TID-15898)
**MC MILLAN, R. N. H.,** Aspects of stability studies, 17: 10984
**MC QUILLAN, A. D.,** Crystal structure of hydrides, 17: 11237
**MC WHINNIE, D. J.,** Effects of $\gamma$ radiation on mouse testis, 17: 10361 (TID-15852)
**MC WILLIAMS, Paul,** Solution of general least squares problem, 17: 11065 (LA-2367(Add.))
**MECH, J. F.,** Deflection methods for 50-Mev proton beam, 17: 11807 (TID-17829)
**MECHAM, W.,** Fluoride volatility processing of enriched fuels, 17: 10744 (TID-13765)
**MECKELBURG, H.,** Stability of metal bonding adhesives, 17: 11175
**MEHTA, M. L.,** Polynomials encountered in distribution function of spacings, 17: 11063 (BNL-757)
**MELDOLESI, U.,** Effects of x radiation on urinary excretion, 17: 10463
**MELETTI, P.,** Embryonic transplant as research medium, 17: 10386
**MELKANOFF, M. A.,** Interaction of deuterons with nuclei, 17: 11676
**MENARIK, E. V.,** Gamma recording by bremsstrahlung beam, 17: 11555
**MENGELKAMP, Bernhard,** Pressure ionization chamber for $\gamma$ measurements, 17: 11015
**MENTKOVSKII, Yu. L.,** Partial wave scattering amplitudes of charged particles. II., 17: 11572
**MERCER, Alan,** Evaluation of radioactive decay data, 17: 10547
**MERCER, T. T.,** Cascade impactor operating at low volumetric flow rates, 17: 10775 (LF-5)
**MERCKX, K. R.,** Measurement of cylindrical shapes, 17: 11259 (HW-71521(Rev.))
**MERGEN, Francois,** Chronic $\gamma$ irradiation of pitch pine-oak forest, 17: 10362 (TID-16254)
**MERIGGI, E.,** Modifications of neurons of Gasser ganglion, 17: 10461
**MERMAZ, M.,** Ericson fluctuations in $Al^{27}(d,\alpha)Mg^{25}$, 17: 11675
**MESCHI, David J.,** Thermodynamic functions for solids from dissociation pressure data, 17: 10607 (UCRL-10189)
**MESHCHEROV (METSHCHEROV), R. A.,** Acceleration and extraction of ions in cyclotron, 17: 11778 (BNL-767(p.254-77))
**MESKAUSKAS, J.,** Blood vessels of irradiated rats, 17: 10485 (NP-12251 (p.99-113))
**MESSIAEN, A. M.,** Scattering behavior of a cold plasma cylinder, 17: 11856
**METZ, D. J.,** Radiation-induced polymerization of $\alpha$-methylstyrene, 17: 11285
**MEYER, L.,** Bone marrow cell transfusions, 17: 10292 (BNL-6106)
**MEYER, Robert A.,** Boron carbide–graphite nuclear control-rod material, 17: 11085 (GA-3064)
**MEYER, Robert E.,** Reduction of O on passive Zr, 17: 10623
**MEYER-PUNDT, G.,** Quantization of electrodynamic field, 17: 11575
**MICHAEL, Norman,** Inorganic ion-exchange resins, 17: 10710
**MICHAELIS, Hans,** Nuclear energy—competitive source of electricity, 17: 10251
**MICHAUDON, Andre,** Resonant interaction of neutrons with U-238, 17: 11655
**MICKLEM, H. S.,** Graft-vs.-graft immunological tolerance in radiation chimeras, 17: 10270
**MICKLES, James,** Antiradiation compounds. II. Dithiocarbamates, 17: 10428
**MIELCARSKI, Mieczyslaw,** Extraction of U and Pu chlorides, 17: 10765
**MIKHAIL, R.,** Effect of radiation on synthesis of HCN, 17: 10704
**MIKHAILOV, A. I.,** Interaction time between beam and target, 17: 11813
**MIKHALENKOV, V. S.,** Position-electron annihilation in alloys, 17: 11275
**MIKHEEV, G. F.,** Efficiency of radioisotope applications in national economy, 17: 10888
**MIKLAVZIC, U.,** Proton-proton scattering, 17: 11677
**MIKULSKI, Jan,** Radiometric studies on extraction of metal ions. II., 17: 10768
**MILBURN, Richard H.,** Electron scattering by polarized photon field, 17: 11549
**MILLAR, C. H.,** Lattice parameters for NPU and CANDU fuel elements in $D_2O$, 17: 11939 (CRL-75)
**MILLER, D. P.,** Nuclear particle tracks in Si, 17: 11272
**MILLER, Donald G.,** Determining nonlinear constant in vapor pressure equations, 17: 10620
**MILLER, J.,** Reactions $(\gamma,n)$ in C-12, O-16 and Ca-40, 17: 11672
**MILLER, J. F.,** Semiconducting properties of rare earths, 17: 11296 (AD-278352)
**MILLER, Richard S.,** Extrusion of $UO_2$ and $ThO_2$–$UO_2$ fuels, 17: 11161 (CEND-153(Vol.II)(p.135-54))
**MILLER, W. F.,** Energy-dependent multiple scattering of neutrons, 17: 11595 (TID-15571)
**MILLER, Wade N.,** Radiopulmonogram, 17: 10280
**MILLERS, A.,** Radiation effects on plants treated with N fertilizers, 17: 10442
**MILLIES, P.,** Thermal energy of nuclear origin, 17: 11619 (CEA-2172)
**MILLS, Darrel Leroy,** Cadmium sulfide as nuclear radiation detector, 17: 11006 (NP-12376)
**MILLS, R. G.,** Persistent current in superconducting solenoid, 17: 11404
**MILSTED, J.,** Nuclear properties of Eu-145, Eu-146, Eu-147, Gd-146, and Gd-147, 17: 11719
**MINARDI, E.,** Nonlinear effects from Vlasov's equation, 17: 11848
**MINC, S.,** Extraction of U(VI) and Fe(III), 17: 10766
**MINTS (MINTZ), A. L.,** Cyclic accelerators for high energies, 17: 11769 (BNL-767(p.91-9))
**MIRONOV, E. S.,** Acceleration and extraction of ions in cyclotron, 17: 11778 (BNL-767(p.254-77))
**MISAWA, Yoshiaki,** DNA-synthesizing peripheral blood cells studied by uptake of $H^3$-thymidine. III., 17: 10291
**MITCHELL, A. C.,** Proton scattering by Ni-64 and Zn-64, 17: 11643 (UCRL-6930)
**MITCHELL, G. E.,** Thresholds observed in $(\alpha,n)$ and $(p,n)$ reactions, 17: 11715
**MITROPAN, I. M.,** Oscillations of plasma in a pulsed electrodeless discharge, 17: 11892
**MIWA, Hiroshi,** Screw-type spin arrangements, 17: 11413
**MODIANO, G.,** Genetic experiments in Borek-Ryan effect, 17: 10382
**MODICA, S.,** Effects of x radiation on urinary excretion, 17: 10463
**MONAHAN, J. E.,** Analysis of $\gamma$ spectra, 17: 11444
**MONAHAN, J. E.,** Lifetimes of radioactive sources, 17: 11628 (TID-15849)
**MONCRIEF, E. C.,** Processing of decayed Zr–U alloy fuel, 17: 10742 (ORNL-TM-447)
**MONDA, Minoru,** Double pion photoproduction, 17: 11564
**MONK, Robert G.,** Evaluation of radioactive decay data, 17: 10547
**MONOSZON, N. (H.) A.,** Two-stage 300-Bev proton circular accelerator, 17: 11768 (BNL-767(p.84-90))
**MONTES DE OCA, Hector,** Radiation response in tissue culture, 17: 10429
**MONTET, G. L.,** Galvanomagnetic properties of graphites, 17: 11103 (TID-16243)
**MONTET, G. L.,** Random paths on plane nets with internal traps, 17: 11907 (TID-15885)
**MONTI, D.,** Decay mode $K^+ \to \pi^+ + \pi^+ + \pi^- + \gamma$, 17: 11523
**MOORE, Betty C.,** Chromosomal aberration gradients in Tradescantia anthers, 17: 10454
**MOORE, J. G.,** Radiation effects on ovarian and cervical cancer cells, 17: 10261
**MOORE, R. H.,** Complex formation by actinide elements in fused KCl–$AlCl_3$ solvents, 17: 10586 (HW-SA-2597)
**MOORE, R. H.,** Immiscibility gap in LiCl–KCl–$AlCl_3$, 17: 10587 (HW-SA-2621)
**MOORE, R. L.,** Solvent extraction of Cs by dipicrylamine, 17: 10731 (HW-SA-2620)
**MOORE, S. A.,** Diffusion of Fe and Cr in beta U, 17: 11079 (ANL-FGF-334)
**MOORE, Sophie,** Neutron cross section newsletter, No. 7, 10/62, 17: 11613 (BNL-768)
**MORGAN, D. J.,** Chemical methods of radiation dosimetry, 17: 10998 (AERE-R-4189)
**MORGENTHALER, A. C.,** Air and gas cleaning operations, 17: 10846 (HW-61840)
**MORI, Hazime,** Collective motion of particles, 17: 11414
**MORI, Hazime,** Ultrasonic attenuation in liquid He, 17: 11415
**MORIN, F. J.,** Specific heats of transition metal superconductors, 17: 11380
**MORITA, M.,** Structure of $2^+$ states in even-even nuclei, 17: 11698

**MOROZOV, V. M.**, Optical measurements on accelerated ions, 17: 10928
**MOROZOVA, I. M.**, Activation energy spectra in escape of Ar and He from minerals, 17: 10830
**MOROZOVA, N. G.**, Radiometry of granules of activated Y, 17: 11029
**MORREY, J. R.**, Complex formation by actinide elements in fused KCl–AlCl$_3$ solvents, 17: 10586 (HW-SA-2597)
**MORRIS, E.**, Equation of state of U in critical region, 17: 11183 (AWRE-O-61/62)
**MORRIS, J. W.**, Thermoelectric converter for SNAP, 17: 11314 (NAA-SR-7288)
**MORRISON, J. D.**, Prog. rpt. on high-strength and heat-resistant alloys, 4–6/62, 17: 11075 (AD-278043)
**MORTLAND, Max M.**, Crystallization of Mg and Al hydroxides, 17: 10619
**MOSCICKI, Wlodzimierz**, Determining age of samples with C-14, 17: 10834
**MOSER, H. C.**, Ionization and dissociation in $PCl_3$ and $P_2Cl_4$, 17: 10630
**MOSES, V.**, Measuring radioactivity on two-dimensional paper chromatograms, 17: 10543
**MOSHINSKY, Marcos**, Wigner coefficients for the SU$_3$ group, 17: 11928
**MOSKVIN, N. A.**, Piezospectroscopic effect in LiF, 17: 11360
**MOSSOTTI, Victor G.**, Atomic absorption spectra of V, Ti, Nb, Sc, Y, and Re, 17: 10549
**MOSZKOWSKI, Steven A.**, Simulation of hard core by velocity dependence, 17: 11921
**MOTE, Jim D.**, Plastic behavior of polycrystalline aggregates, 17: 11196 (UCRL-10152)
**MOTLEY, R. M.**, Excitation of electrostatic plasma near ion cyclotron frequency, 17: 11851
**MOTSAREV, G. V.**, Chlorination of Si-containing monomers and polymers under radiation, 17: 10715
**MOTZ, H.**, One-dimensional theory of *t-l* plasma confinement, 17: 11852
**MOWERY, Alfred L., Jr.**, Variational method for reactor analysis, 17: 11972
**MRNKA, Miroslav**, Recovery of uranyl sulfate by tri-*n*-octylamine, 17: 10756
**MUELLER, D.**, Sizing of targets of x-ray sources, 17: 11353
**MUELLER, Dieter**, Three-body problem of nuclear physics, 17: 11583
**MUELLER, Gerhard O.**, KWIP—kinetics with plotter, 17: 11950 (KAPL-M-EC-28)
**MUELLER, Heinrich**, Sensitivity of thickness measurements, 17: 10978
**MUELLER, K. G.**, Theory of contraction of positive columns, 17: 11874
**MUELLER, Volkhard F.**, Compton scattering on protons, 17: 11574
**MUIR, H. M.**, Rare earth chalcogenides, 8/60–6/61, 17: 11292 (AD-277043)
**MULDREW, D. B.**, Intensity of the outer Van Allen belt, 17: 11453
**MULFORD, Robert N. R.**, Thermodynamic functions for Pu, 17: 10593 (LA-2813)
**MULLER, Norbert**, Carbon-13 splittings in fluorine NMR spectra, 17: 11356
**MULLIKIN, T. W.**, Problems in mathematics of multiple scattering, 17: 11490 (RM-3221-PR)
**MURAY, J. J.**, Shower development and heating in waveguide structure with 800-Mev electron beam, 17: 11794 (SLAC-3)
**MURPHREE, Oddist D.**, Behavior in rat after cranial x irradiation, 17: 10430
**MURPHREE, R. L.**, Growth and sexual development of prenatally irradiated cattle, 17: 10422
**MURPHY, A. H.**, Prog. rpt. on 2400°F forging die system, 9–12/62, 17: 11081 (ASD-TR-7-886(Vol.VII))
**MURPHY, J. E.**, Space vehicle shielding, 17: 11902 (ORNL-3317)
**MURPHY, J. E.**, Star density produced by 24-Bev proton beam in heavy concrete, 17: 11489 (ORNL-3367)
**MURR, William E.**, High-temperature irradiation test of $UO_2$ fuels, 17: 11254 (BMI-1608)
**MURRAY, Beatrice E.**, X-ray-induced mutation in *Medicago sativa L.*, 17: 10398
**MURRAY, Raymond L.**, Neutron transport theory, 17: 11592 (NP-12480)
**MURRAY, Raymond L.**, Variational method for reactor analysis, 17: 11972
**MURROW, J. L.**, Portable DOP tester for inspection of high-efficiency filters, 17: 10922
**MURTAS, G. P.**, Linear polarization of photons in multi-Bev region, 17: 10896 (LNF-62/107)
**MURTHA, B. E.**, Economics of powder packed fuel elements, 17: 11142 (CEND-153(Vol.1)(p.3-10))
**MURTHA, B. E.**, Pneumatic vibratory compaction of $UO_2$, 17: 11145 (CEND-153(Vol.1)(p.45-59))
**MURTHY, N. S. Satya**, Neutron and x-ray diffraction studies of non-stoichiometric metal hydrides, 17: 10578 (ANL-FGF-332)
**MURTHY, N. Sreedhara**, Transition probabilities of BeO, 17: 10624
**MUSTAFIN, K. S.**, Definition of plasma parameters in Ne–Hg mixture, 17: 11883
**MUZIKAR, C.**, Mossbauer effect and ferroelectric properties of ionic crystals, 17: 10639
**MYERS, H. P.**, Paramagnetism of dissolved Mn in $\alpha$ and $\beta$ brasses, 17: 11297 (AE-95)
**MYNZATU, I.**, Polarization of neutrons scattered on C-12, 17: 11741
**MYZNIKOV, K. P.**, Interaction time between beam and target, 17: 11813

# N

**NACHMAN, J. F.**, Intermediate phases of intra-rare-earth binary systems, 17: 11186 (DRI-2080)
**NADLER, Samuel B.**, Calibration of thyroid uptake systems, 17: 10343
**NAGL, J.**, Adiabatic microcalorimeter for measurement of radioactivity. I., 17: 11023
**NAGORNAYA, L. L.**, Scintillation properties of 1,3-oxazole derivatives in polystyrene, 17: 11227
**NAHARIN, A.**, Turnover rate of Zn determined by Zn-65, 17: 10275
**NAKAJIMA, Yoshiharu**, Discoloration of irradiated polyvinyl chloride, 17: 11281
**NAKATANI, Hiroshi**, Phonon-phonon interaction, 17: 11411
**NASTYUKHA, A. I.**, Energy distributions in strong current toroidal discharge, 17: 11884
**NATANSON, Ludwik**, Fast neutrons elastically scattered on Ca, 17: 11593 (PAN-354/I-A)
**NAUDET, G.**, Thermal energy of nuclear origin, 17: 11619 (CEA-2172)
**NAUMOV, I. I.**, Determination of Au by activation, 17: 10573
**NAYMOV, V. A.**, Scandium, Y, Ce, Nd, and Gd orthovanadates, 17: 10663
**NAZAROV, T. S.**, Hafnium and Ge foils for nuclear studies, 17: 11178
**NEBEL, B. R.**, Effects of $\gamma$ radiation on mouse testis, 17: 10361 (TID-15852)
**NEBEL, D.**, Potentiometric investigations on Pu, 17: 10654
**NEED, John L.**, Indium-117 and In-117m in $Sn^{120}(p,\alpha)$ reaction, 17: 11696
**NEED, John L.**, Isomer ratio in $Sn^{120}(p,\alpha)^{117\,117}$, 17: 11697
**NEEL, Louis**, Electron irradiation of Fe–Ni alloy, 17: 11274
**NEFKENS, B. M. K.**, Photon bombardment of Li, 17: 11728
**NELSON, Arne**, Distribution of Pu in mice, 17: 10260
**NELSON, J. L.**, Chemical effluents technology, 17: 10851 (HW-73337 (p.158-237))
**NELSON, J. W.**, Thresholds observed in $(\alpha,n)$ and $(p,n)$ reactions, 17: 11715
**NELSON, P. A.**, Mixing in flow parallel to rod bundles having square lattice, 17: 10804 (WCAP-1607)
**NELSON, Sterling L.**, Conservation of He by radioactive Ar measurements, 17: 11948 (HW-SA-2584)
**NEMENOV, L. L.**, Hydrogen–D bubble chamber in magnetic field, 17: 10930
**NEMENOV, L. L.**, Reaction $\pi + N \rightarrow \pi + \gamma + N$, 17: 11476 (JINR-P-1111)
**NEMENOV, L. M.**, Acceleration and extraction of ions in cyclotron, 17: 11778 (BNL-767(p.254-77))
**NESTEROV, V. M.**, Gamma effects on insulating materials. II., 17: 11277
**NEUFELD, Jacob**, Instabilities in plasma-beam system in magnetic field, 17: 11863
**NEUSEN, K. F.**, Rod burnout heat flux tests for Pathfinder, 17: 11977 (ACNP-62028)
**NEVITT, M. V.**, Alloy chemistry of transition elements, 17: 11180 (ANL-FGF-337)
**NEVITT, M. V.**, System UC–PuC, 17: 11181 (ANL-FGF-345)
**NEWKIRK, L. L.**, Lithium-6 and $Li^7(n,2n)$ cross sections, 17: 11722
**NEWLON, C. E.**, Critical interaction potentials of $H_2O$-moderated $UF_4$ arrays, 17: 11460 (TID-17633)
**NEWMAN, Leonard**, Solvent extraction of Th by TTA, 17: 10727 (BNL-6099)
**NEWMAN, Leonard**, Synergistic effect in solvent extraction, 17: 10729 (BNL-6188)
**NEWTON, Roger G.**, Angular momentum poles of S matrix for spin 1/2 particles, 17: 11913

**NEWTON, Roger G.**, S matrix in terms of its angular momentum poles, 17: 11914
**NEWTON, V.**, Conversion of pyrrole to pyridine, 17: 10669 (NP-tr-942)
**NGUYEN, Van-hieu**, Radiative corrections in neutron decay, 17: 11469 (JINR-E-1100)
**NICHOLSON, K. P.**, Neutron temperature measurement using Lu, 17: 11586 (AAEC/TM-164)
**NICOLETTI, B.**, Radiation-produced recessive lethals in Drosophila, 17: 10393
**NIELL, Arcadio M.**, Digital computer in development of positron scanning procedure, 17: 10357 (BNL-6572)
**NIELSEN, N. O.**, Leukemogenic effect of whole-body γ irradiation, 17: 10354 (BNL-6105)
**NIESE, E.**, Radiation stability of ion exchangers, 17: 11276
**NIEWODNICZANSKI, H.**, Scattering of deuterons on Al-27 nuclei, 17: 11625 (PAN-204)
**NIKI, H.**, Formation of benzene in radiolysis of acetylene, 17: 10698
**NIKOLAEV, A. V.**, Reciprocal effect of Th and Ce nitrates on coextraction with TBP, 17: 10760
**NIKOLAICHUK, A. D.**, Hafnium and Ge foils for nuclear studies, 17: 11178
**NIKOL'SKII, V. G.**, Plastification of polyethylene by radiolysis, 17: 10688
**NIKULISHEV, V. I.**, Elution of U(VI) ions from sulfocation columns, 17: 10660
**NILAN, R. A.**, Relation of embryo structure to effects of x rays in barley, 17: 10453
**NILSSON, I.**, Measuring radioactivity in the human body, 17: 10963
**NININGER, H. H.**, Meteorite with unique features, 17: 10838
**NITTA, Isamu**, Discoloration of irradiated polyvinyl chloride, 17: 11281
**NOELDEKE, G.**, Relative isotopic position of Os-186, 17: 11744
**NORDHEIM, L. W.**, Resonance absorption in materials with grain structure, 17: 11604
**NORMAN, A.**, Void and pressure by fission track nucleation during power bursts, 17: 11952 (NAA-SR-7086)
**NORTON, L. J.**, Binary systems of Tc-99 with transition elements, 17: 11220
**NORWITZ, George**, Colorimetric determination of Th, 17: 10561
**NORWOOD, W. D.**, Therapeutic removal of Pu in humans, 17: 10336
**NOTAY, W.**, X-ray effects on bilirubin and biliverdin, 17: 10376
**NOTLEY, M. J. F.**, Irradiation of hydraulic rabbit specimens, 17: 11256 (CRFD-1119)
**NOVEY, T.**, Rapid beam ejector at Cosmotron, 17: 11785 (BNL-6678)
**NUDELMAN, H.**, Prog. rpt. on 2400°F forging die system, 9–12/62, 17: 11081 (ASD-TR-7-886(Vol.VII))
**NURMI, I.**, Beam delineation in x-ray diagnostics, 17: 10273
**NURUSHEV, S. B.**, Parameters of generalized nuclear diffraction model, 17: 11307 (JINR-P-1009)
**NURZYNSKI, J.**, Scattering of deuterons on Al-27 nuclei, 17: 11625 (PAN-204)

## O

**OAKES, R. J.**, Flux trapping, 17: 11369
**O'BRIEN, Vivian**, Axi-symmetric magnetic fields, 17: 11355
**OCHSENFELD, W.**, Applicability of dibutyl ether for preparation of irradiated fuel by extraction, 17: 10755
**ODEH, Farouk**, Critical fields of superconducting films, 17: 11399
**OEHME, R.**, Relativistic dispersion theory, 17: 11521
**OEHME, Reinhard**, Branch point trajectories in complex angular momentum plane, 17: 11495 (TID-17731)
**OEN, O. S.**, Energetic atoms in crystal lattices, 17: 11348
**O'FARRELL, E.**, PM-3A hazards report corrections, 17: 11985 (MND-M3A-2496(Vol.I)(Add.))
**OFENGENDEN, R. G.**, Pulse analyzer with memory device, 17: 11043
**OGANESYAN, V.**, Control of cyclotrons operating with multiply charged ions, 17: 11818
**OGAWA, Kiyoshi**, Damping of plasma oscillations, 17: 11870
**OHNISHI, Shun-ichi**, Discoloration of irradiated polyvinyl chloride, 17: 11281
**OKAMOTO, Kazuto**, Effect of tensor force on photonuclear sum rule, 17: 11733
**OKUBO, Susumu**, Unitary symmetry in strong interaction. II., 17: 11557
**OLCOTT, Eugene L.**, Pyrolytic graphite in rocket motors, 17: 11076 (AD-278371)
**O'LEARY, William J.**, Extrusion of $UO_3$ and $ThO_2$–$UO_3$ fuels, 17: 11161 (CEND-153(Vol.II)(p.135-54))
**OLES, A.**, Energetic particle interactions with atomic nuclei at mountain altitudes, 17: 11454
**OLIVIERI, G.**, Radiation-produced recessive lethals in Drosophila, 17: 10393
**OLOFSSON, A.**, X-ray emission spectrography, 17: 10950
**OLSHANSKAYA, N. I.**, Dielectric losses induced in polymers by radiation, 17: 11278
**OLSHANSKAYA, N. I.**, Gamma effects on insulating materials. II., 17: 11277
**OLSON, Edwin H.**, Growth of single crystals of Pb, Cd, and Bi, 17: 10502 (IS-542)
**ONCESCU, M.**, Electrode for (n,n) and (n,γ) radioactive logging, 17: 10836
**ONG, L. D. Y.**, Urine U excretion data, 17: 10305 (HASL-120)
**ONLEY, D. S.**, Partial-wave analysis of electron scattering. II., 17: 11710
**OPARIN, E. M.**, Investigation of target temperature, 17: 11817
**OPHEL, T. R.**, Level of Al-27 at 2.21 Mev, 17: 11686
**OPHEL, T. R.**, Resonance of $Mg^{26}(p,\gamma)$ reaction, 17: 11680
**ORAEVSKII, V. N.**, Stability of oscillations of plasma, 17: 11888
**ORLANDINI, K. A.**, Determination of Ge in mineral specimens, 17: 10574
**ORLENKO, B. F.**, Proton scattering on Mg-24 at 6.9 Mev, 17: 11743
**ORLENKO, B. F.**, Scattering of 6.9-Mev protons by Cr and Zn, 17: 11656
**ORSZAGH, Andrzej**, Effects of radiation on aliphatic polyethers, 17: 10678 (PAN-306/XVII)
**OSBORNE, Darrell W.**, Thermodynamic properties of $ZrH_2$, $ZrD_2$, $YH_2$, and $YD_2$, 17: 10597 (TID-15795)
**OSHER, John E.**, Loss of plasma through magnetic aperture of traps, 17: 11841 (AEC-tr-5620)
**OSTER, Ludwig**, Coulomb interactions in strong magnetic field. I., 17: 11538
**OSTERMANN, F.**, Deformation behavior of Nb, Ta, Mo, and W. II., 17: 11223
**OTT, D. G.**, Thin layer chromatography apparatus, 17: 10926
**OTTO, W.**, Drift velocities of ions and electrons, 17: 11430
**OVCHINNIKOV, E. P.**, Symmetrical ring phasotron, 17: 11776 (BNL-767 (p.181-97))
**OWCZARSKI, W. A.**, Thermocouples for temperature measurements of Zy-2 weldments, 17: 11105 (TID-17734)
**OWEN, George E.**, Neutrons from reaction $F^{19}(d,n)Ne^{20}$, 17: 11636 (TID-17720(p.8-14))
**OWEN, R. B.**, State of scintillation techniques, 17: 10964
**OXENIUS, J.**, Nonlinear effects from Vlasov's equation, 17: 11848
**OXENIUS, J.**, Radiation losses from hot spherical plasma, 17: 11855
**OZHDYAN, L.**, Application of sparks in scintillation techniques, 17: 11037

## P

**PADERNO, V. N.**, Properties of metal–ceramic specimens, 17: 11215
**PAINE, R. M.**, Prog. rpt. on intermetallic compounds, 1–3/62, 17: 11082 (BBC-113)
**PALCOS, M. C.**, Production of radioisotopes with synchrocyclotron, 17: 10676 (NP-12231)
**PALENZONA, D. L.**, Variability after irradiation of seeds, 17: 10391
**PALENZONA, D. L.**, X-ray effect on wheat species, 17: 10381
**PALFREY, T. R., Jr.**, High-energy photoprotons from light nuclei, 17: 11704
**PALMER, H. E.**, Radiological physics, 17: 10849 (HW-73337(p.29-76))
**PANCHENKOV, G. M.**, Isotopic exchange of O, 17: 10634
**PANDYA, S. P.**, Collective vibrations in Si-30, 17: 11661
**PANTUEV, V. S.**, Application of sparks in scintillation techniques, 17: 11037
**PAPINEAU, L.**, Ericson fluctuations in $Al^{27}(d,\alpha)Mg^{25}$, 17: 11675
**PAQUETTE, D. R.**, Profiles of Balmer lines in H plasma, 17: 11860
**PAQUETTE, G.**, Oceanographic literature of Santa Barbara channel area, 17: 10826 (TID-17722)
**PARDI, A. J.**, Carrier distillation of impurities in $U_3O_8$, 17: 10538 (TID-16295)
**PARISH, N. R.**, Growth and sexual development of prenatally irradiated cattle, 17: 10422
**PARK, J. F.**, Toxicity of inhaled Pu in dogs, 17: 10322

**PARKER, Hermon M.**, Countercurrent flow in semi-infinite gas centrifuge, 17: 11054 (UVA-279-63U)
**PARKER, Hermon (Herman) M.**, Countercurrent flow in semi-infinite gas centrifuge, 17: 11055 (UVA-280-63U)
**PARKINSON, W. C.**, Prog. rpt. on 83-inch cyclotron, 10–12/62, 17: 11806 (TID-17735)
**PARR, J. Gordon**, Martensite transformations in Zr, Ti, and Ti–Cu alloys, 17: 11239
**PARRY, W. E.**, Poles of Green functions, 17: 11517
**PARSHAD, Ram**, Coincidence technique for transistor decade counter, 17: 11021
**PASECHNIK, M. V.**, Scattering of 6.9-Mev protons by Cr and Zn, 17: 11656
**PASECHNIK, V. A.**, Thermodynamic potential of resins during ion exchange, 17: 11252
**PASTERNAK, R. A.**, Prog. rpt. on sorption of gases on metal surfaces, 8/15–11/15/62, 17: 11193 (TID-17635)
**PASTERNAK, R. A.**, Prog. rpt. on oxidation and nitridation of Nb, 6–8/62, 17: 10602 (TID-16820)
**PATIGNY, P.**, Radiolysis of aqueous solutions of Te. I., 17: 10693
**PATT, H. J.**, Materials function of N plasma at 15000°K, 17: 11877
**PAUL, W.**, Localization of brain tumors, 17: 10278
**PAULEVE, Jean**, Electron irradiation of Fe–Ni alloy, 17: 11274
**PAULY, Helmut**, Metabolism by bacteria after x-ray irradiation, 17: 10468
**PAUTHENET, R.**, Uranates of Co and Mn, 17: 10633
**PAVLOV, Yu. S.**, Strong pulse magnetic fields, 17: 11442
**PAVLOVA, E. N.**, Impurities in formation of luminescence centers in ZnS–Cu, 17: 11228
**PAWLOWSKI, Zdzislaw**, Analysis of energy of particles in disintegration of nuclei by neutron bombardment, 17: 11670
**PEARS, C. D.**, Thermal conductivity and expansion of Pt alloys, 17: 11199 (UCRL-13061)
**PEARSALL, S. G.**, Transport of fission products through soil, 17: 10820 (BNL-6554)
**PEARSON, Gary A.**, Electron-energy distribution in H with magnetic fields, 17: 11839 (UCRL-10366)
**PEDERSON, D. O.**, Current-switching circuitry, 17: 10918 (UCRL-9035 (Rev.))
**PEISACH, M.**, Analytical aspects of delayed neutron emission, 17: 10534 (IA-784)
**PELLAM, John R.**, Torsional oscillations in rotating He, 17: 11402
**PELLEGRINI, C.**, Damping constants of electron oscillations in synchrotron, 17: 11787 (LNF-62/96)
**PELLOUX, Regis M. N.**, Analysis of fracture surfaces by electron microscopy, 17: 11185 (D1-82-0169)
**PELMAN, S. G.**, Distribution of radioactive Y salts in animals, 17: 10443
**PELTE, D.**, Luminescent spectra of Tl salt solutions, 17: 10650
**PENCZEK, Stanislas**, Polymerization of bis(chloromethyl)-3,3-oxetane, 17: 10694
**PENMAN, J.**, Irradiation of cerebral astrocytomata, 17: 10438
**PENROSE, Roger**, Asymptotic properties of fields, 17: 11401
**PEPPARD, D. F.**, Extraction of U(VI) by phosphates and phosphonates, 17: 10745 (TID-15773)
**PEPPARD, D. F.**, Separation of Y-91 and Pm-147, 17: 10746 (TID-15792)
**PEPPARD, D. F.**, Structural aspects of organophosphorus extractants, 17: 10748 (TID-17726)
**PEPPER, C. E.**, Carrier distillation of impurities in $U_3O_8$, 17: 10538 (TID-16295)
**PEPPER, Stephen V.**, Design of quadrupole channel, 17: 11789 (NYO-10251)
**PERCIVAL, D.**, Photodecomposition of organic acids, 17: 10697
**PEREL'MAN, T. L.**, Temperature field in cylindrical fuel element, 17: 10810
**PERELYGIN, V. P.**, Radiography of spontaneous nuclear fission, 17: 10535 (JINR-P-1118)
**PERETTI, J.**, Superconductivity of transition elements, 17: 11370
**PEREZ-TAMAYO, Ruy**, Rejection of skin homografts in rabbits. II., 17: 10425
**PERKINS, M.**, Apparatus for cylindrical graphite specimens, 17: 11934 (AERE-R-3453)
**PERRET, Robert F. D.**, Nuclear bomb effects computer, 17: 10845 (CEX-62.2)
**PERRIGO, L. D.**, Piping autoradiography, 17: 11004 (HW-SA-2651)
**PERRINGS, J. D.**, Thin layer chromatography apparatus, 17: 10926
**PESHKIN, Murray**, Spin of $\Xi^-$ from angular asymmetry of its decay, 17: 11545
**PETERKOP, R. K.**, Distortion of incident s-wave in ionization of H by electrons, 17: 11359
**PETERKOP, R. K.**, Strong bond and exchange in collisions of electrons with H atoms, 17: 11361
**PETERSON, G. E.**, Fluorescent lifetime of Tb, 17: 10626
**PETERSON, N. L.**, Diffusion of Fe and Cr in beta U, 17: 11079 (ANL-FGF-334)
**PETERSON, P. J.**, Reactor irradiation of U-impregnated graphite, 17: 11261 (LAMS-2814)
**PETROCK, K. F.**, Portable DOP tester for inspection of high-efficiency filters, 17: 10922
**PETROV, V. I.**, Investigation of target temperature, 17: 11817
**PETROVA, L. A.**, Stabilization of $\beta$ solution in Zr alloys, 17: 11213
**PETUKHOV, V. A.**, Cyclic accelerators for high energies, 17: 11769 (BNL-767(p.91-9))
**PFEFFER, Richard L.**, Air waves from nuclear explosions, 17: 10837
**PFEIFER, M.**, Steam generators for gas-cooled reactors, 17: 12000
**PFIRSCH, D.**, Microinstability in inhomogeneous plasmas, 17: 11875
**PFUNDT, Heimar**, Determination limits for impurities in Al, 17: 10571
**PHEASANT, Richard**, Ultrasonic filling of cladding with ceramic powders, 17: 11162 (CEND-153(Vol.II)(p.163-94))
**PHILLIPS, J. C.**, Gapless superconductivity, 17: 11405
**PHILLIPS, W. A.**, Plutonium alpha air monitor, 17: 11012 (UCRL-6692)
**PICARD, F.**, Excited states in N-14, 17: 11623 (NP-12496)
**PICKUP, Eric**, Bubble chamber track-centering device, 17: 11000 (BNL-6094)
**PIETRA, Romano**, Neutron activation analysis of Al, 17: 10546
**PIETRI, C. E.**, Separation and determination of Pu in Pu–U fuel elements, 17: 10737 (NBL-189)
**PIETRI, Charles E.**, Separation and determination of soluble Si in Pu, 17: 10548
**PIETSCHMANN, H.**, New resonances, 17: 11464 (AFOSR-2978)
**PIGNOTTI, Alberto**, K* spin and isovector kaon charge, 17: 11542
**PILKUHN, H.**, Cross sections in the multiperipheral model, 17: 11529
**PINASCO, Santiago**, Electrometric amplifier, 17: 10899 (NP-12229)
**PINCUS, P. A.**, NMR modes in magnetic material. I., 17: 11379
**PIPKIN, F. M.**, Pressure shifts of hfs of atomic N, 17: 11387
**PIRT, L.**, Action of bromoform and chloroform on pyrroles, 17: 10668 (NP-tr-941)
**PISANI, G.**, Picture from irradiation of brain in rats, 17: 10459
**PISANI, G.**, Ultrastructure of Purkinje cells in irradiated animals, 17: 10460
**PISARENKO, A. P.**, Resistance to irradiation of silicate-filled rubber vulcanizates, 17: 11286
**PITLYK, Paul J.**, Localization of brain lesions with $I^{131}$-labeled polyvinylpyrrolidone, 17: 10287
**PIXLEY, R. E.**, Parity of 2.13-Mev first excited state of B-11, 17: 11707
**PIZZARELLO, Donald J.**, Survival time after whole-body radiation, 17: 10467
**PLAKSIN, I. N.**, Polonium-210 $\alpha$ radiation for quantitative control of concentration products, 17: 10570
**PLAKSIN, I. N.**, Solvent extraction of rare earths, 17: 10764
**PLANT, W. R.**, Eddy current testing. I. Theory, 17: 10815 (TID-16062)
**PLATEK, Walter A.**, Ion exchange in PyHCl–NaCl–Dowex-50, 17: 10747 (TID-15923)
**PLATTE, W. N.**, Welding Nb and Nb alloys, 17: 11242
**PLZAK, V.**, Influence of chemical agents on radiation lethality, 17: 10481 (NP-12251(p.34-46))
**PLZAK, V.**, Radioprotective effects of p-aminopropiophenone, 17: 10483 (NP-12251(p.67-89))
**PODGORNYI, I. M.**, Loss of plasma through magnetic aperture of traps, 17: 11841 (AEC-tr-5620)
**PODLESNYI, G. G.**, Diffusion of plasma in magnetic field, 17: 11881
**POETZL, Karl**, Analytical chemistry in alkali metal nitrate melts, 17: 10575
**POLAK, L. S.**, Conference on radiation chemistry, Moscow, October 10–14, 1960, 17: 10721
**POLUBOYARINOV, D. N.**, Beryllium oxide porous ceramics, 17: 11226
**POOL, Chalmers S.**, Behavior in rat after cranial x irradiation, 17: 10430

**POPOV, N. I.**, Strontium-90 in Atlantic surface waters, 17: 10835
**POPOVYCH, O.**, Absorption studies in 8-quinolinol family, 17: 10667 (TID-15433)
**POPPE, C. H.**, Excited state of the $\alpha$ particle, 17: 11526
**PORAT, D.**, Electron beam intensity and position measurement at CEA, 17: 11797 (TID-16967)
**PORNEUF, A.**, Chemical properties of extruded $UO_2$, 17: 11160 (CEND-153(Vol.II)(p.131-4))
**PORTER, C. E.**, Atomic radiative transition probabilities, 17: 11373
**POSTNIKOV, V. I.**, Efficiency of radioisotope applications in national economy, 17: 10888
**POTTIER, Jacques**, High-frequency EM fields and plasma confinement, 17: 11845
**POVARNIN, P. I.**, Burnout during flow of subcooled water through tubes, 17: 10806 (AEC-tr-5602)
**POVH, B.**, Alpha spectrum from $(\gamma,\alpha)$ on V-51, 17: 11678
**POVH, B.**, Delbruck scattering of 17-Mev photons, 17: 11745
**POWELL, Jack E.**, Formation constants of rare earth complex species, 17: 10501 (IS-458)
**POYTON, H. G.**, Apron for x-ray protection, 17: 10873
**POZZI, L. V.**, X ray effects on Drosophila recessive lethals, 17: 10392
**PRAEG, Rudolf**, Contrast intensification of scintigraphs, 17: 11046
**PRESTON, M. A.**, Nucleon-nucleon potential of Green, 17: 11527
**PRIBILLA, W.**, Measurement of Fe-59 and Cr-51 activities at body surface of patients, 17: 10271
**PRICE, LeRoy**, Determination of branching ratio $\Gamma(\eta \to \pi^+\pi^-\gamma)/\Gamma(\eta \to \pi^+\pi^-\pi^0)$, 17: 11552
**PRICE, P. B.**, Uranium concentrations in natural crystals, 17: 10555
**PRIMAK, William**, Gamma-induced expansion of LiF, 17: 11266 (TID-15896)
**PROCTOR, D. G.**, Performance of black vs. gray control rods, 17: 12029
**PROKOPENKO, V. S.**, Proton scattering on Mg-24 at 6.9 Mev, 17: 11743
**PROKOPENKO, V. S.**, Scattering of 6.9-Mev protons by Cr and Zn, 17: 11656
**PROKOSHKIN, D. A.**, Thermodiffusion in W–Be systems, 17: 11214
**PRON, G. F.**, Boron carbides in C reduction of rare earth mixtures with B, 17: 10662
**PROSSER, F. W., Jr.**, Reaction $C^{13}(p,\gamma)N^{14}$ and states in N-14, 17: 11714
**PROTASEVICH, V. I.**, Definition of plasma parameters in Ne–Hg mixture, 17: 11883
**PROWSE, D. J.**, $\pi$-$\sigma$ Interaction in $\tau$-decay, 17: 11528
**PSZONICKI, Leon**, Evaporation of trace impurities, 17: 10951
**PUCHEROV, M. M.**, Proton scattering on Mg-24 at 6.9 Mev, 17: 11743
**PUCHEROV, N. N.**, Scattering of 6.9-Mev protons by Cr and Zn, 17: 11656
**PUGLIESE, Adolfo**, Radioactivity in fish from Lake Maggiore, 17: 10349
**PUGLISI, M.**, Electronic loading of resonant cavity of accelerators, 17: 11792 (RT/EL(62)15)
**PUGLISI, M.**, Phase discriminator for tuning cavity resonator, 17: 11791 (RT/EL(62)14)
**PUIG, J.-R.**, Radiolytic and thermal stability of terphenyls, 17: 10689
**PUSCHEL, W.**, Decay mode $K^+ \to \pi^+ + \pi^+ + \pi^- + \gamma$, 17: 11523
**PUSHKAREV, V. V.**, Enrichment of radioactive Cs solutions by foaming method, 17: 1706
**PUYN, U.**, Measurement of Fe-59 and Cr-51 activities at body surface of patients, 17: 10271

## Q

**QUERZOLI, R.**, "AdA" accumulator ring for electrons and positrons, 17: 11820

## R

**RAAB, Bernard**, Power-producing shield for space reactors, 17: 12039
**RABIN, H. R.**, Absorption of mesons in emulsion nuclei, 17: 11679
**RABOY, S.**, Analysis of $\gamma$ spectra, 17: 11444
**RABOY, S.**, Lifetimes of radioactive sources, 17: 11628 (TID-15849)
**RACK, Edward P.**, Radiation dose I scavenger effects recoil C-11 reactions in cyclohexane, 17: 10701
**RACK, Edward P.**, Reaction mechanisms for $(\gamma,n)$ activated $C^{11}$ reactions in liquid cyclohexane, 17: 10675 (IS-425)
**RADICELLA, R.**, Production of radioisotopes with synchrocyclotron, 17: 10676 (NP-12231)
**RADWAN, M.**, Structure of alloys by autoradiography, 17: 11208
**RAINEY, W. T., Jr.**, Thermal and radiation stability of alternative gas coolants, 17: 10516 (ORNL-TM-475)
**RAITH, W.**, Polarization of electron beams transmitted through Fe foils, 17: 11577
**RAJEWSKY, Boris**, Metabolism by bacteria after x-ray irradiation, 17: 10468
**RAKA, E. C.**, Beam current measurements in AGS, 17: 11782 (BNL-6645)
**RALKOVA, Jarmila**, Diffusion of radioisotopes in glass, 17: 10642
**RAMSDEN, W.**, X-ray instrumentation, 17: 10948
**RANDEN, K.**, Neutron streaming in $D_2O$ pipes, 17: 11588 (AE-98)
**RANKIN, M.**, DCX-2 performance curves, 17: 11835 (ORNL-3387)
**RANKIN, M. O.**, Coincidence-count $\alpha$ particulate air monitor, 17: 10532 (HW-SA-2554)
**RANKIN, M. O.**, Instrumentation, 17: 10852 (HW-73337(p.238-97))
**RANNINGER, J.**, Linear response function for quantum mechanical system, 17: 11582
**RANZ, E.**, Sulfur sensitization of emulsions, 17: 10649
**RAO, L. Madhav**, Scattering of cold neutrons by BeO, 17: 11671
**RAO, V. Surya**, CIR team solved corrosion, deposition problems, 17: 11136
**RAPISARDA, C.**, Effects of radiation on urinary excretion, 17: 10463
**RAPPE, Edwin F.**, Bubble chamber track-centering device, 17: 11000 (BNL-6094)
**RASMUSSEN, N. C.**, Neutron kinetics and cross sections in fast non-moderating assemblies, 17: 11598 (TID-16304)
**RATAY, R. P.**, Separation of U from trivalent Fe, 17: 10752 (GAT-Z-5035)
**RATH, G.**, Production gas chromatography, 17: 10955
**RATNER, L. G.**, External proton beam of ZGS, 17: 11800 (TID-17642)
**RATNER, L. G.**, Unseparated antiproton beam for counter experiments, 17: 11803 (TID-17691)
**RAU, Jayaseetha**, Relaxation phenomena in spin and harmonic oscillator systems, 17: 11920
**RAUH, E. G.**, Vaporization and thermodynamic properties of US and UOS, 17: 10598 (TID-15796)
**RAUSCHER, G. P., Jr.**, Intermediate phases of intra-rare-earth binary systems, 17: 11186 (DRI-2080)
**RAY, Robert D.**, Strontium-85 in evaluation of bone metastases, 17: 10279
**RAY, William H.**, Stack gas $\beta$ monitor, 17: 11017
**RAY-CHAUDHURI, S. P.**, Cysteamine protection of x-ray-induced aberrations, 17: 10492
**RAYMOND, J. R.**, Radiological monitoring of ground $H_2O$, 17: 10822 (HW-SA-2566)
**RAYMUND, Ann B.**, Influence of chemical agents on irradiated enzyme, 17: 10480 (NP-12251(p.22-33))
**RAYMUND, Ann B.**, Radiation effects on pyridine nucleotide-linked dehydrogenase activity, 17: 10479 (NP-12251(p.12-21))
**READ, Merrill S.**, Rat feeding studies with $\gamma$-irradiated foods, 17: 10350
**REALE, C.**, Electric resistivity by lattice vacancies in metals, 17: 11231
**REARDON, W. A.**, Critical mass experiments with $Pu(NO_3)_4$, 17: 11459 (HW-SA-2432(Rev.))
**REAVIS, J. P.**, Statistics in health physics, 17: 10869 (Y-KB-7)
**REDDI, M. M.**, Shipping containers for radioactive materials. I., 17: 10780 (NYO-9859)
**REDFIELD, A. G.**, NMR saturation in Li, 17: 11392
**REDMAN, W. C.**, Capture-to-fission ratio determination, 17: 11963 (TID-17738)
**REEDER, Paul L.**, Excitation function for $C^{12}(\pi^-,\pi^-n)C^{11}$ reaction, 17: 11648 (UCRL-10312)
**REEDER, Paul L.**, Nuclear reactions induced by pions and protons, 17: 11650 (UCRL-10531)
**REESE, W.**, Properties of He-3, 17: 10603 (TID-17721)
**REGAN, W. H.**, Uranium recovery from unirradiated fuel elements, 17: 10728 (BNL-6148)
**REGAN, W. H.**, Volatility reprocessing of reactor fuels, 17: 10730 (BNL-6195)
**REGAN, William H.**, Meeting on calcination and fixation of high level wastes, 17: 12044 (TID-7646)
**REHFELD, C. E.**, Gingival ulceration induced in beagles, 17: 10296 (COO-226(p.35-49))
**REID, F. J.**, Semiconducting properties of rare earths, 17: 11296 (AD-278352)

**REILLY, J. J.**, Uranium recovery from unirradiated fuel elements, 17: 10728 (BNL-6148)
**REILLY, J. J.**, Volatility reprocessing of reactor fuels, 17: 10730 (BNL-6195)
**REITAN, A.**, Analytic properties of S matrix in perturbation theory, 17: 11483 (NP-12436)
**REKOVA, L. P.**, Thermionic emission of metals in different gases, 17: 11435
**RESIBOIS, P.**, Three-particle scattering operator, 17: 11513
**RETTIG, Thomas A.**, Cation exchange in acetone–$H_2O$–HCl, 17: 10733 (IS-466)
**REYNOLDS, G. T.**, Muon capture on C, 17: 11541
**REYNOLDS, J. M.**, Electron transport in Zn at liquid-He temperatures, 17: 11378
**REYNOLDS, J. T.**, Partial-wave analysis of electron scattering. II., 17: 11710
**REYNOLDS, W. C.**, HECTIC-II, IBM-7090 FORTRAN program for heat transfer analysis, 17: 10795 (IDO-28595)
**RHODES, Harvey H.**, THD2—temperature distribution in slab with internal heat generation, 17: 10797 (KAPL-M-EC-27)
**RIBON, Pierre**, Resonant interaction of neutrons with U-238, 17: 11655
**RIBRAG, M.**, Thermal absorption and scattering cross sections of natural Ne, 17: 11620 (EANDC(E)-10.U)
**RICARD, Jean-Paul**, Atomic propulsion of ships, 17: 10252
**RICHARDS, H. K.**, Alkaline thermionic converters, 17: 11837 (TID-16215)
**RICHARDSON, R. L.**, Packing of spheres for maximum density, 17: 11088 (HW-73057)
**RICHMOND, W. J.**, Prog. rpt. on power reactors, 10/62, 17: 11096 (NMI-7256)
**RIECKHOFF, K. E.**, Faraday rotation studies of PMR in Nd ethylsulfate, 17: 10617
**RIEDINGER, A. B.**, Carbon transport and corrosion in GCR, 17: 11981 (GA-2630)
**RIKENGLAS, L. E.**, Kinetic theory of diode filled with plasma, 17: 11437
**RINGO, G. R.**, System to obtain higher space resolution in nuclear emulsions, 17: 11333 (TID-17640)
**RIPAN, Raluca**, Condensation of Na molybdate, 17: 10611 (UCRL-Trans-894(L))
**RIVIERE, M. R.**, Appearance of lymphoid tumors in mice, 17: 10406
**ROAN, Patricia L.**, Post-irradiation glomerulosclerosis, 17: 10433
**ROBERGE, Pierre**, X-ray-induced polymerization of vinyl iodide, 17: 11284
**ROBERTS, J. H.**, System to obtain higher space resolution in nuclear emulsions, 17: 11333 (TID-17640)
**ROBERTSON, J. S.**, Kinetics of Ca-47 and Sr-85 in man, 17: 10293 (BNL-6108)
**ROBERTSON, James S.**, Digital computer in development of positron scanning procedure, 17: 10357 (BNL-6572)
**ROBINSON, J. M.**, Critical heat flux of polyphenyl coolants, 17: 10800 (NAA-SR-7954)
**ROBINSON, K.**, Electron beam intensity and position measurement at CEA, 17: 11797 (TID-16967)
**ROBINSON, Mark T.**, Energetic atoms in crystal lattices, 17: 11348
**ROBINSON, Peter D.**, Generalized momentum operators in quantum mechanics, 17: 11339 (WIS-AEC-34)
**ROBINSON, Peter D.**, Hypervirial theorems for scattering theory, 17: 11909
**ROBINSON, Peter D.**, Virial theorem in scattering theory, 17: 11908
**ROBLIN, M. J.**, Dislocation mobility and interactions in Mg, 17: 11182 (AROD-3394.1)
**RODDICK, Ronald G.**, Tunnel diode circuit analysis, 17: 10890 (ANL-6634)
**RODGERS, S. J.**, Final rpt. on decontamination of radioactive components, 17: 12042 (MSAR-61-34)
**RODIER, J.**, Equipment decontamination at Marcoule, 17: 10761
**RODRIGUEZ, J.**, Production of radioisotopes with synchrocyclotron, 17: 10676 (NP-12231)
**RODRIGUEZ-PASQUES, R. H.**, Calibration of radioisotopes by CNEA, 17: 10677 (NP-12235)
**ROEBBELEN, Christa**, Spermatocyte division in tuplidae. III., 17: 10402
**ROES, John B.**, Flat-plate solar thermoelectric conversion panels, 17: 11300 (ASD-TDR-62-214)
**ROGERS, L. B.**, Absorption studies in 8-quinolinol family, 17: 10667 (TID-15433)
**ROHRER, H.**, Thermal conductivity of superconductors, 17: 11406
**ROMANKO, G. D.**, Principle of invariance under inversion, 17: 11520
**ROMANOVA, T. A.**, Uranium salts in nuclear emulsions, 17: 11039
**ROMANTSEV, E. (Ye.)**, Protection against radiation, 17: 10870 (JPRS-16995)
**ROMASKO, E. A.**, Temperature field in cylindrical fuel element, 17: 10810
**ROMINE, Richard A.**, Hazards rpt. for Northrop reactor, 17: 12025 (NP-12299)
**RON, Amiram**, Absorption of waves in plasmas, 17: 11864
**ROOK, J. R.**, Decay of $K^-$ mesic atoms, 17: 11512
**ROOT, M.**, Influence of chemical agents on radiation lethality, 17: 10481 (NP-12251(p.34-46))
**ROOT, M.**, Radioprotective effects of p-aminopropiophenone, 17: 10483 (NP-12251(p.67-89))
**ROSE, A.**, Neutron temperature measurement using Lu, 17: 11586 (AAEC/TM-164)
**ROSE, John E.**, Construction of muscle-equivalent environmental radiation meter, 17: 11011 (TID-17824)
**ROSEN, D.**, Excitation of x-irradiated isolated frog nerve, 17: 10417
**ROSEN, S.**, System UC–PuC, 17: 11181 (ANL-FGF-345)
**ROSEN, Victor J.**, Post-irradiation glomerulosclerosis, 17: 10433
**ROSEN, Victor J., Jr.**, Tumors of pancreas in irradiated and nonirradiated rat, 17: 10432
**ROSENBLATT, Gerd M.**, Thermodynamics of suboxide vaporization, 17: 10645
**ROSENBLUM, Bruce**, Resonances of plasma sphere in magnetic field, 17: 11858
**ROSENBLUTH, M. N.**, Cyclotron radiation from hot plasma, 17: 11849
**ROSENBLUTH, Marshall N.**, Low-frequency stability of nonuniform plasmas, 17: 11847
**ROSENTHAL, Fred**, Prepyriform activity after x irradiation, 17: 10373
**ROSENTHAL, Marcia W.**, Removal of Pu from blood, 17: 10327
**ROSOFF, Betty**, Distribution and excretion of radioactive rare earth compounds, 17: 10308 (TID-17542)
**ROSS, C. W.**, Radiation effects on thermocouples and resistance thermometers, 17: 11273
**ROSS, John S.**, Isotope shift in Yb. I., 17: 10625
**ROSSI-TORELLI, M.**, Radiostrontium in blood and bones of rats, 17: 10347
**ROSVOLL, Randi V.**, Thyroid cancer study in children, 17: 10262
**ROTH, E.**, Preparation of $D_2O$ by isotopic exchange, 17: 11058
**ROTH, Edward S.**, Phantom gage, 17: 10913 (TID-17740)
**ROTHMAN, S. J.**, Diffusion of Fe and Cr in beta U, 17: 11079 (ANL-FGF-334)
**ROURKE, F. M.**, Cascade mass spectrometer, 17: 10909 (TID-15951)
**ROUSSEAU, Yves**, Quenching of Hg resonance radiation, 17: 10685
**ROUSSET, P.**, Prog. rpt. on forming and irradiation of UC, 4–6/62, 17: 11110 (EURAEC-387)
**ROWLAND, R. E.**, Local distribution and retention of Ra in man, 17: 10309 (TID-17644)
**ROY, Donald H.**, Neutron transport theory, 17: 11592 (NP-12480)
**ROY, O. Z.**, Coronary arteriography by single x-ray exposure, 17: 10267
**ROY, Rustum**, Solid-phase reactions at high pressures, 17: 10503 (NP-12359)
**ROZENTAL, O. M.**, Pulse analyzer with memory device, 17: 11043
**RUANE, R. F.**, Neutron captures in U-235 and natural B, 17: 11629 (TID-15884)
**RUBCHINSKII (RUBCHINSKIJ), S. M.**, Cyclic accelerators for high energies, 17: 11769 (BNL-767(p.91-9))
**RUBCHINSKII (RUBCHINSKIJ), S. M.**, Electronic systems for proton synchrotron, 17: 11763 (BNL-767(p.32-47))
**RUBINSON, William**, Lead x rays that accompany Po-210 decay, 17: 11616 (BNL-6166)
**RUDERMAN, Malvin A.**, Neutrino pair emission by stellar plasma, 17: 11446
**RUDY, E.**, Graphite-coated particle fuel production, 17: 11174
**RUETSCHI, Paul**, Oxidation of H and D on rotating disk electrode, 17: 10628
**RUFFATO, C.**, Radiation effects on collagens. III., 17: 10465
**RUHL, W.**, Pair-production cross sections, 17: 11516
**RUSH, J. J.**, Inelastic scattering of slow neutrons, 17: 11602
**RUSSELL, J.**, Polarization of neutrons from photodisintegration of D, 17: 11551
**RYAN, J. L.**, Anion exchange of anionic chloro complexes of hexavalent ac-

tinides, 17: 10585 (HW-SA-2596)
**RYBIN (RIBIN), S. N.**, Acceleration and extraction of ions in cyclotron, 17: 11778 (BNL-767(p.254-77))
**RYDEN, O.**, Fuel-channel temperature scanning equipment, 17: 10992
**RYDEN, O.**, Xenon predictor for reactors, 17: 10993
**RYKOWSKI, H.**, Blood vessels sterilized by γ radiation, 17: 10450
**RYON, A. D.**, Prog. rpt. on chemical technology, 6/62, 17: 10741 (ORNL-TM-313)
**RYON, A. D.**, Prog. rpt. on chemical technology, 1/61, 17: 10743 (ORNL-TM-457)
**RYVKIN, V. B.**, Temperature field in cylindrical fuel element, 17: 10810
**RYZHKOV, E. M.**, Ion association in solutions. XI., 17: 10656

## S

**SAALFELD, Fred E.**, Hydrolysis of rare-earth carbides, 17: 10591 (IS-499)
**SABEU, M.**, Determination of neutron flux distribution, 17: 11608
**SABEU, M.**, Self-shielding coefficient for Au foils, 17: 11609
**SACERDOTI, G.**, Trapped flux in a superconducting ring, 17: 11291
**SADEGHI, A.**, Excited states in N-14, 17: 11623 (NP-12496)
**SAFFORD, G. J.**, Inelastic scattering of slow neutrons, 17: 11602
**SAFTIC, B.**, Measuring x-ray energy, 17: 10975
**SAGDEEV, R. S.**, Stability of oscillations of plasma, 17: 11888
**SAHL, Wilhelm**, Fast neutrons and fast reactors, 17: 11970
**SAITO, G. H.**, Physics tests on PWR-1 Seed 2, 17: 11991 (WAPD-PWR-TE-81)
**SAKAMOTO, Yoshiyuki**, Quasi-elastic scattering, 17: 11736
**SAKITA, Bunji**, Momentum dependence of phase shifts and magnitude of coupling constants, 17: 11922
**SAKURAI, J. J.**, New mesons and resonances in strong interaction physics, 17: 11496 (TID-17742)
**SALESSE, M.**, Permissible performance limits of fuel elements in graphite–$CO_2$ reactors, 17: 11999 (AEC-tr-5610)
**SALMON, P. G.**, Fission chamber detectors, 17: 10987
**SALVADOR, Jack Gilbert**, Current-switching circuitry, 17: 10918 (UCRL-9035(Rev.))
**SALZANO, F. J.**, Distribution of U and Ce between liquid Bi–Mg and NaCl–KCl–$MgCl_2$, 17: 10581 (BNL-639)
**SALZMAN, W. R.**, Prog. rpt. on high-strength and heat-resistant alloys, 4–6/62, 17: 11075 (AD-278043)
**SAMADDAR, S. N.**, Wave propagation in waveguide containing inhomogeneous plasma, 17: 11843
**SAMOILOV, O. Ya.**, Uranyl nitrate extraction, 17: 10770
**SAMPSON, J. B.**, Resonance absorption in materials with grain structure, 17: 11604
**SAMSONOV, G. V.**, Sintering of powders of refractory compounds, 17: 11170 (AEC-tr-5604)
**SAMSONOV, G. V.**, Thermodynamic potential of resins during ion exchange, 17: 11252
**SAMUEL, David**, Mechanism of anodic oxidation, 17: 11138
**SANDERSON, E. A.**, Inelastic α-particle excitation, 17: 11682
**SANDLIN, Glen**, Structure of liquid Hg, 17: 11232
**SANDOVAL, Antonio A.**, Ionization and dissociation in $PCl_3$ and $P_2Cl_4$, 17: 10630
**SANDRU, P.**, Electrode for (n,n) and (n,γ) radioactive logging, 17: 10836
**SANFORD, W. R.**, Reduced pressure backflow preventer, 17: 10515 (ORNL-3380)
**SANI, L.**, Proton-recoil counter exposed to neutron source, 17: 11002 (CNEN-158)
**SANIELEVICI, A.**, Adiabatic microcalorimeter for measurement of radioactivity. I., 17: 11023
**SANTORO, A.**, Modifications of neurons of Gasser ganglion, 17: 10461
**SARAEVA, V. V.**, Radiolysis and radiation-induced oxidation of diisopropyl ether, 17: 10705
**SARGENT, C. P.**, Polarization of neutrons from photodisintegration of D, 17: 11551
**SARVELLA, Patricia**, Relation of embryo structure to effects of x rays in barley, 17: 10453
**SASAKURA, Y.**, Anomalous particle loss across magnetic field, 17: 11868
**SATHER, Lois A.**, Radiation effects on wheat, 17: 10374
**SATO, Akira**, Electromagnetic structure of the nucleon, 17: 11559
**SATO, Humitaka**, Thermodynamics of spectrum of cosmic rays, 17: 11456
**SAUER, Kenneth**, Energy conversion apparatus in photosynthesis, 17: 10257 (UCRL-10549)
**SAUERWALD, Franz**, High-ductile state of Al–Zn alloys, 17: 11247
**SAUNDERS, R. A.**, Dragon irradiation program, 17: 12005
**SAUR, A. J.**, Seebeck coefficient apparatus, 17: 11316 (NAA-SR-Memo-6741)
**SAUVAGE, Gilles**, Elastic electron-proton scattering, 17: 11506
**SAVINO, G.**, Hepatic function in cancer patients, 17: 10464
**SAVINO, G.**, Nucleic acids in neurons of irradiated rats, 17: 10466
**SAVINSKAYA, A. A.**, Vanadium and Nb carbides in steel, 17: 11209
**SAWADA, T.**, Interaction of deuterons with nuclei, 17: 11676
**SAX, N. Irving**, Environmental levels of Ra, 17: 10529 (ANL-6637(p.59-84))
**SCARAMUZZI, F.**, Space charge limited currents in superfluid He, 17: 11312 (LNF-62/106)
**SCARASCIA, G. T.**, Morphological mutations in "Cappelli" wheat, 17: 10390
**SCARL, D. B.**, Muon capture on C, 17: 11541
**SCHAEFFER, O. A.**, Cosmic ray produced Ar-37 and Ar-39 in meteorites, 17: 11448 (BNL-6545)
**SCHALET, A.**, Induced changes in female germ cells of Drosophila. VII., 17: 10415
**SCHEARER, L. D.**, Large He-3 nuclear polarization, 17: 11730
**SCHECTER, Larry**, Neutron cross sections and nuclear spectroscopy, 17: 11627 (TID-15088)
**SCHEER, J. A.**, Measurement of photoproton spectrum from C-12, 17: 11749
**SCHEER, Max**, X-ray bremsstrahlung in a betatron, 17: 11821
**SCHEITLIN, W.**, Shock and anuria after irradiation of uterine myomatosus, 17: 10496
**SCHEY, Harry M.**, Collisions of electrons and positrons with atomic H, 17: 11390
**SCHIEBOLD, E.**, Cesium-137 in γ radiography, 17: 10817
**SCHILLING, Edward L.**, Radiation response in tissue culture, 17: 10429
**SCHLECHT, Alfons**, Measurement and control in sugar industry with isotopes, 17: 10887
**SCHLIEPE, R.**, Polarization of electron beams transmitted through Fe foils, 17: 11577
**SCHLUDI, N. H.**, Economics of gas-cooled, $D_2O$-moderated, U reactor, 17: 12001
**SCHMETS, J.**, Modification of U isotope in irradiation, 17: 11253 (BLG-140)
**SCHMIDT, A.**, Action of parathyroid hormone on Sr and Ca in bone and blood serum, 17: 10264
**SCHMITT, J. M.**, Comparison of DBPP and DSBPP with TBP for recovery of U and Th, 17: 10738 (ORNL-3374)
**SCHMITT, R. A.**, Prog. rpt. on rare earths in meteorites, 3/15/62, 17: 10821 (GA-2985)
**SCHMITZ, G.**, Materials function of N plasma at 15000°K, 17: 11877
**SCHMORAK, Marcel**, Virtual electron capture in Ni-59, 17: 11709
**SCHMUTZER, Ernst**, Relationship of bispinor to spinor theory, 17: 11931
**SCHNEIDER, Werner**, Influence of magnetic dipole electric quadrupole interaction on angular correlations, 17: 11386
**SCHNIEWIND, H.**, Preparing labeled drugs by neutron activation, 17: 10683
**SCHOLZ, H.**, Applicability od dibutyl ether for preparation of irradiated fuel by extraction, 17: 10755
**SCHOLZ, W.**, Delbruck scattering of 17-Mev photons, 17: 11745
**SCHRADER, Franz**, Kinetochore of the hemiptera, 17: 10404
**SCHRANZ, P.**, Magnetic amplifiers in reactor instrumentation, 17: 10990
**SCHREIBER, F.**, Circuits of two-condition, flip-flop stages with complementary transistors, 17: 10921 (SCL-T-460)
**SCHROEDER, O. W.**, Nuclear reactors in service of medicine, 17: 12026
**SCHUBERT, Friedrich**, Outlet of particles in cyclic accelerator, 17: 11825
**SCHUETZ, G.**, Ionization voltage chambers with a-c feed, 17: 11026
**SCHUHL, G.**, Reactions (γ,n) in C-12, O-16 and Ca-40, 17: 11672
**SCHULKE, A. A.**, Radiation effects in diamonds, 17: 11288
**SCHULTEN, Rudolf**, Gas-cooled high-temperature reactor, 17: 11998 (AEC-tr-5484)
**SCHULTZ, Guenther**, Probe theory at average and low pressures, 17: 11876
**SCHULTZ, J.**, Comparison of η, r, and r' decays, 17: 11553
**SCHULZ, G. J.**, Resonance in scattering of electrons in He, 17: 11408
**SCHULZE, Werner**, High-ductile state of Al–Zn alloys, 17: 11247
**SCHURICHT, V.**, Surface moisture measurements with neutrons, 17: 10925
**SCHUSKE, C. L.**, Shipping radioactive materials, 17: 10862 (RFP-290)

**SCHWABE, K.**, Potentiometric investigations on Pu, 17: 10654
**SCHWEBEL, A.**, Determination of $\beta$-emitting radionuclides in aqueous formamide, 17: 10526 (ANL-6637(p.29-31))
**SCHWEITZER, Donald G.**, Graphite problems in air-cooled reactors, 17: 11184 (BNL-758)
**SCHWEITZER, Donald G.**, Radiation damage in graphite. I., 17: 11255 (BNL-6083)
**SCHWIDTAL, Klaus**, Superconductivity of La foils, 17: 11251
**SCHWINK, Ch.**, Stress-strain curve of Ni, 17: 11234
**SCOTT, Bruce L.**, Delta-function potential in a box, 17: 11910
**SCOTT, F. R.**, Separation of emission light during plasma injection, 17: 11854
**SCOTT, L. M.**, Excretion of U from mixed exposures, 17: 10311 (Y-KB-1)
**SCOTT, William D.**, Deformation of polycrystalline LiF, 17: 11197 (UCRL-10435)
**SCOTTI, Antonio**, Theory of nucleon-nucleon scattering in strip approximation, 17: 11498 (UCRL-10028)
**SEALE, W. A.**, Bombardment of C-12 by Li-6 ions, 17: 11718
**SEARCY, Alan W.**, Thermodynamic functions for solids from dissociation pressure data, 17: 10607 (UCRL-10189)
**SEARS, Kendrick A.**, Alpha dose from surface and volume deposits of Pu-239, Th-228, and Ra-226, 17: 10301 (COO-226(p.78-85))
**SEARS, Kendrick A.**, Radium dosimetry, 17: 10302 (COO-226(p.86-94))
**SEDLACK, Richard E.**, Localization of brain lesions with $I^{131}$-labeled polyvinylpyrrolidone, 17: 10287
**SEEFELDT, W.**, Contamination and decontamination studies related to BWR, 17: 11959 (TID-15779)
**SEEGER, A.**, Depolarization and scattering of neutrons by ferromagnetic crystals, 17: 11610
**SEGEL, S. L.**, Nuclear quadrupole interactions and resonance frequencies. I., 17: 10592 (IS-520)
**SEIGEL, Benjamin V.**, Effect of $D_2O$ on ectromelia viral infection, 17: 10285
**SELIVANOV, G. I.**, Hydrogen–D bubble chamber in magnetic field, 17: 10930
**SELTZER, Stanley**, Secondary $\alpha$-deuterium isotope effect in decomposition of $\alpha$-phenylethylazo-2-propane, 17: 10665 (BNL-6174)
**SEMENOV, A. G.**, Electron paramagnetic resonance spectrometers, 17: 10929
**SEMENOV, S. S.**, Effect of injector focusing on $\gamma$ intensity in betatron, 17: 11816
**SEMENOV, S. T.**, Burnout during flow of subcooled water through tubes, 17: 10806 (AEC-tr-5602)
**SENA, L. A.**, Ion-atom interaction in gas, 17: 11340 (AEC-tr-5615)
**SENGUPTA, Dipak L.**, Static potential attained by cylinder in moving and low-density plasma, 17: 11844
**SENKO, Michael E.**, Crystal structure of $KH_2F_3$, 17: 10608 (UCRL-10197)
**SERAPHIM, D. P.**, Alloy concentration for ideal superconductivity transitions, 17: 11376
**SETZWEIN, Andreas**, Gas-cooled high-temperature reactor, 17: 11998 (AEC-tr-5484)
**SEVAST'YANOV, B. A.**, Theory of branching stochastic processes, 17: 10520 (NP-tr-946)
**SEVERLEIN, Juergen**, X-ray bremsstrahlung in a betatron, 17: 11821
**SHADMI, Y.**, Shell model analysis of the level structure of Ar-41, 17: 11626 (PUC-1962-89)
**SHAKHOVA, K. I.**, Constitution diagram of Ti–Nb–Cr alloy, 17: 11212
**SHANKAR, J.**, CIR team solved corrosion, deposition problems, 17: 11136
**SHAPAR, A. V.**, Scintillation counter with $CaF_2$ crystal, 17: 11044
**SHAPIRO, F. L.**, Linear ion bunching device, 17: 11814
**SHAW, G. L.**, Modification of model for $\pi^- + p \rightarrow \pi^- + \pi^+ + n$, 17: 11535
**SHCHELKIN, K. I.**, Strange particles, 17: 11556
**SHEELY, W. F.**, Mechanical properties of Nb–O alloys, 17: 11219
**SHEFFIELD, J. C.**, Cascade mass spectrometer, 17: 10909 (TID-15951)
**SHEFFIELD, J. C.**, Pulsed electrostatic analyzer for ion energy determinations, 17: 11010 (TID-16311)
**SHEFFIELD, J. C.**, 360° Tandem mass spectrometer, 17: 10912 (TID-16312)
**SHELDON, E.**, Angular correlation symmetries, 17: 11684
**SHELINE, Raymond K.**, Rotational structure in Ho-166, 17: 11729
**SHELTON, Neil**, Rotational structure in Ho-166, 17: 11729
**SHER, Neil C.**, Void fractions in parallel rod arrays, 17: 10812
**SHERIDAN, P. B.**, Formula translation and combinatorial systems, 17: 11064 (CERN-62-35)
**SHERMA, Joseph**, Separation of metal ions from mixtures by electrochromatography, 17: 10753
**SHERRARD, R.**, Reactor data logging systems, 17: 11946 (HW-SA-2549)
**SHESTOPEROV (SHESTOPIEROV), V. Ya. (J.)**, Energetic particle interactions with atomic nuclei at mountain altitudes, 17: 11454
**SHEVCHENKO, A. K.**, Millimeter radiospectroscope, 17: 10931
**SHEVCHENKO, V. I.**, Blood coagulation disturbances in x irradiation, 17: 10446
**SHEWCHUCK, Sergey**, Condensation of Na molybdate, 17: 10611 (UCRL-Trans-894(L))
**SHILKOV, K. S.**, Cylinder iron-free betatron with axial magnetic focusing, 17: 11823
**SHIMIZU, Ben**, Hazards rpt. for Northrop reactor, 17: 12025 (NP-12299)
**SHIPMAN, Thomas L.**, Radiation death from accidental excursion. IX., 17: 10874
**SHIRAYAMA, Kazuhiso**, Properties of radiation shielding concrete, 17: 11218
**SHIRLEY, D. A.**, Anomalous quadrupole coupling in Eu ethylsulfate, 17: 11647 (UCRL-10202)
**SHIRLEY, D. A.**, Nuclear alignment of Ce-137m, Ce-137, Ce-139, Ce-141, and Ce-143, 17: 11705
**SHKUROPAT, P. I.**, Parallel work of controlled spark gaps, 17: 11048
**SHOCKLEY, M. E.**, Heat transfer for out-of-reactor cooling of PRTR fuel elements, 17: 10793 (HW-72097(Rev.))
**SHONKA, Francis R.**, Construction of muscle-equivalent environmental radiation meter, 17: 11011 (TID-17824)
**SHOWAK, Walter**, Solid solubility of Zr in Cu, 17: 11240
**SHRADER, E. F.**, Neutron production by deuteron bombardment of B-11, 17: 11693
**SHTRANIKH, I. V.**, Linear ion bunching device, 17: 11814
**SHUGART, Howard A.**, Hfs measurements on Ag-105, 17: 11706
**SHUKEJLO, I. A.**, Two-stage 300-Bev proton circular accelerator, 17: 11768 (BNL-767(p.84-90))
**SHUMYATSKII, B. Y.**, Tungsten enthalpy from 350 to 2000°C, 17: 11207
**SHUSTROV, B. N.**, Mass spectrometer with two-stage ion separation, 17: 10932
**SHWE, Hla, Mean** life of $\pi^0$ meson, 17: 11500 (UCRL-10118(Rev.))
**SIBILLA, P.**, Bone metabolism of Sr-85 and Sr-89, 17: 10348
**SIBLEY, W. A.**, Radiation equilibrium of F and M centers in KCl, 17: 11393
**SIDHU, S. S.**, Neutron and x-ray diffraction studies of non-stoichiometric metal hydrides, 17: 10578 (ANL-FGF-332)
**SIDOROVA, I. I.**, Reactor feedback dynamics, 17: 12004
**SIEGEL, Elsie**, Distribution and excretion of radioactive rare earth compounds, 17: 10308 (TID-17542)
**SIEWERT, Howard R.**, Consecutive-reaction model systems, 17: 10610 (UCRL-10575)
**SIGMUND, Peter**, Magnetism of free electron gas, 17: 11584
**SILIN, I. N.**, Extrapolation of experimentally determined relationships, 17: 11472 (JINR-P-1046)
**SILKER, W. B.**, Effectiveness of high coagulant feed in reducing reactor effluent radioisotope concentrations, 17: 12041 (HW-SA-2192)
**SIMMONS, E. M.**, Reactor Materials, Vol. 5, No. 3, 1962, 17: 11123
**SIMMONS, E. M.**, Reactor Materials, Vol. 5, No. 4, 1962, 17: 11124
**SIMON, William G.**, Charge distributions for heavy ions at high velocities, 17: 11388
**SIMONIS, W.**, X irradiation of chloroplasts and effect of TPN reduction, 17: 10458
**SIMONOFF, Gabriel N.**, Neutron emission by Dy-156, Tb-153, and Tb-157 compound nuclei, 17: 11645 (UCRL-10099)
**SIMPSON, C. L.**, Atmospheric physics, 17: 10848 (HW-73337(p.1-28))
**SINAEV, A. N.**, Electronic systems for spectrometers, 17: 11049
**SINCLAIR, K. F.**, Scintillation system for inspection of W billets, 17: 10816 (USNRDL-TR-602)
**SINELNIKOV, K. D.**, Magnetic areas in systems with helical magnetic field, 17: 11879
**SINGER, Robert M.**, Graphite problems in air-cooled reactors, 17: 11184 (BNL-758)
**SINGH, J. J.**, Gravimetric determination of La, Gd, and Y, 17: 10568
**SINGH, J. J.**, Reaction $C^{13}(p,\gamma)N^{14}$ and states in N-14, 17: 11714
**SINGH, Virendra**, Regge poles in $\pi N$ scattering, 17: 11546
**SINITSYN, V. V.**, Loss of plasma through magnetic aperture of traps,

17: 11841 (AEC-tr-5620)
**SINITSYN, V. V.**, Separate measurements of energy losses in plasma, 17: 11893
**SINITSYNA, Z. A.**, Formation of amine ion radicals during radiolysis of organic solutions, 17: 10687
**SIRIN, A.**, $K_{\mu e}$ decays and structure of $\Delta S = 1$ currents, 17: 11534
**SIRONI, G. P.**, X ray effects on Drosophila recessive lethals, 17: 10392
**SISAKYAN, N. M.**, Role of lipoprotein in protein synthesis, 17: 10314
**SITENKO, A. G.**, Dynamic friction and diffusion in plasma, 17: 11891
**SJOESTRAND, B.**, Moisture determination by beta-ray transmission, 17: 10981
**SJOESTRAND, Bernt**, Determination of As by activation analysis, 17: 10542
**SKALSKAYA, I. P.**, Diffraction of EM waves on wedge of finite conductivity, 17: 11434
**SKILBREID, O.**, Nuclear properties of Eu-145, Eu-146, Eu-147, Gd-146, and Gd-147, 17: 11719
**SKLAROFF, David M.**, Irradiation syndrome controlled, 17: 10489
**SKLAROFF, David M.**, Treatment of radiation esophagitis, 17: 10269
**SKREB, Yvette**, Photorestoration of fragments by irradiated amoeba, 17: 10410
**SKRYLEV, L. D.**, Enrichment of radioactive Cs solutions by foaming method, 17: 10706
**SKVORTSOVA, N.**, Determination of moisture in peat by neutron method, 17: 10559
**SKY-PECK, Howard H.**, Strontium-85 in evaluation of bone metastases, 17: 10279
**SLAMA, L.**, Prog. rpt. on high-density plasmas, 9/15–12/15/61, 17: 11826 (AD-273961)
**SMALL, Maurice J.**, Radiopulmonogram, 17: 10280
**SMALLER, B.**, Paramagnetic resonance of photolyzed solid $H_2O_2$, 17: 10679 (TID-15898)
**SMIDT, F. A., Jr.**, Electric resistivity of rare-earth alloys, 17: 11190 (IS-477)
**SMIDT, F. A., Jr.**, Scattering of conduction electrons, 17: 11367
**SMILEY, T. B., Jr.**, Beta and $\alpha$ activity in urine, 17: 10525 (ANL-6637 (p.23-8))
**SMIRENKIN, G. N.**, Isodose neutron detector, 17: 11034
**SMIRNOV, S. A.**, Strong pulse magnetic fields, 17: 11442
**SMIRNOV, V. N.**, Polonium-210 $\alpha$ radiation for quantitative control of concentration products, 17: 10570
**SMITH, Alan R.**, Cement for low-background counting facility, 17: 11903 (UCRL-10475)
**SMITH, Alan R.**, Radiation field around high-energy accelerators, 17: 11809 (UCRL-10163)
**SMITH, D. F.**, Thermodynamic properties of Cs chloride and iodide, 17: 10584 (BM-RI-6157)
**SMITH, Frances M.**, Mean life of $\pi^0$ meson, 17: 11500 (UCRL-10118(Rev.))
**SMITH, G. D.**, Health physics monitoring instruments, 17: 10960
**SMITH, G. G.**, Effective U-238 resonance capture integrals, 17: 11667
**SMITH, G. G.**, Equivalence relations for effective resonance integrals, 17: 11668
**SMITH, Harold P., Jr.**, Dynamics of nuclear rocket engines, 17: 12037
**SMITH, J. Chandler**, Protection against intestinal radiation by surgical isolation, 17: 10378
**SMITH, J. H.**, Kinetics of low source reactor startups. I., 17: 11960 (TID-16142(Pt.I))
**SMITH, J. H.**, Kinetics of low source reactor startups, 17: 11961 (TID-16142(Pt.II))
**SMITH, J. H.**, Low-pressure spall thresholds in Cu, 17: 11326 (SC-4747(RR))
**SMITH, June M.**, Lympho-reticular cells in lasting tolerance, 17: 10289
**SMITH, Kenneth**, Collisions of electrons and positrons with atomic H, 17: 11390
**SMITH, Kenneth**, Positron elastic scattering by atomic H, 17: 11328 (TID-15769)
**SMITH, L. H.**, Modification of radiation injury by leukemoid leukocytes, 17: 10283
**SMITH, L. T.**, $\pi$-$\pi$ Interaction in $\tau$-decay, 17: 11528
**SMITH, Maynard E.**, Meteorological knowledge as factor in air pollution control, 17: 10843 (BNL-6538)
**SMITH, R. E.**, CASPER: program for plotting and scaling data, 17: 11066 (ORNL-3394)
**SMITH, Richard J.**, Bibliography on failure of reactor fuels, 17: 11956 (TID-3573)
**SMITHER, R. K.**, Gamma spectrum from Hf-177 thermal-neutron capture, 17: 11711
**SMOLIAR, V.**, Survival of irradiated rats after cysteamine injection, 17: 10488
**SMORODINSKII, Ya. A.**, Radiative corrections in neutron decay, 17: 11469 (JINR-E-1100)
**SMUTZ, Morton**, Growth of single crystals of Pb, Cd, and Bi, 17: 10502 (IS-542)
**SNEIDER, C. J.**, Thin films for measurement of charged-particle ranges, 17: 10911 (TID-16251)
**SNELLING, Margaret D.**, Postoperative irradiation of corneal grafts, 17: 10439
**SNYDER, Rita L.**, X-radiation effect on fumarase activity, 17: 10409
**SNYDER, W. S.**, Interpreting urinalysis data to estimate body burden of Pu-239, 17: 10340
**SNYDER, Walter S.**, Body burden of Pu from urinalysis data, 17: 10524 (ANL-6637(p.13-21))
**SOEDERLUND, B.**, Hand monitor for simultaneous measurement, 17: 10962
**SOHST, Hans**, Breakdown voltages in air, 17: 11426
**SOILA, P.**, Beam delineation in x-ray diagnostics, 17: 10273
**SOINE, T. S.**, Active metal reduction of $PuCl_3$, 17: 10582 (HW-SA-1973)
**SOKOLOV, N. M.**, Physiochemical constants of heavy-oxygen $H_2O$, 17: 10657
**SOKOLOV, S. N.**, Estimate of virtual number of events, 17: 11475 (JINR-P-1085)
**SOKOVISHIN, Y. A.**, Laminar jet outflow of conducting gas with magnetic field, 17: 11352
**SOLARSKI, J. E.**, Profiles of Balmer lines in H plasma, 17: 11860
**SOLIMA, A.**, Variations of fitness factors in irradiated Drosophila, 17: 10384
**SOLOVEV, L. D.**, Dispersion relations in quantum electrodynamics, 17: 11468 (JINR-D-1108)
**SOLOVEV, L. D.**, Infrared singularities and Regge trajectories in electrodynamics, 17: 11470 (JINR-E-1116)
**SOLOWAY, A. H.**, Neutron capture therapy of brain tumors. II., 17: 10282
**SONDER, E.**, Radiation equilibrium of F and M centers in KCl, 17: 11393
**SOROKOVSKAYA, I. A.**, Determination of Eu in rare earth oxides, 17: 10572
**SORRENTINO, R.**, Hepatic function in cancer patients, 17: 10464
**SORRENTINO, R.**, Nucleic acids in neurons of irradiated rats, 17: 10466
**SOSSENSKII (SOSSENSKIJ), N. L.**, Computer for studying particles in synchrotron, 17: 11773 (BNL-767(p.145-60))
**SOWA, E. S.**, Uranium dioxide–NaK slurry as reactor fuel, 17: 11077 (ANL-6644)
**SPEAR, W. G.**, Coincidence-count $\alpha$ particulate air monitor, 17: 10532 (HW-SA-2554)
**SPEARMAN, T. D.**, Pion-pion interactions in states $T = 0$ and $T = 1$, 17: 11544
**SPECTOR, R. M.**, Value of $fa/if$ in $\beta$-decay theory, 17: 11664
**SPEIRS, Robert**, Prog. rpt. on antibody formation, 4/62–3/63, 17: 10255 (TID-17648)
**SPENCER, C. W.**, Liquid Bi penetration into boundaries in Ni, 17: 11241
**SPENCER, Herta**, Distribution and excretion of radioactive rare earth compounds, 17: 10308 (TID-17542)
**SPICER, W. E.**, Effect of band structure on thermionic emission, 17: 11336 (UCRL-6820)
**SPIEGLER, P.**, Void and pressure by fission track nucleation during power bursts, 17: 11952 (NAA-SR-7086)
**SPITZER, R.**, Superselection rules for spin-½ bosons, 17: 11524
**SPREADBOROUGH, J.**, Prog. rpt. on radiation effects on pressure vessel steels, 7–9/62, 17: 11188 (EURAEC-485)
**SQUIRES, Euan J.**, Complex angular momentum in many-channel potential-scattering problems. II., 17: 11501 (UCRL-10209)
**SRIVASTAVA, L. P.**, Martensite transformations in Zr, Ti, and Ti–Cu alloys, 17: 11239
**SRIVASTAVA, Prem P.**, Decay $\Sigma^0 \to \Lambda^0 + \gamma$ in charge-independent $\pi$ interaction, 17: 11488 (NP-12499)
**STAFFORD, G. H.**, Polarization in p-p scattering, 17: 11525
**STAIRS, D. G.**, Slightly inelastic p-d scattering, 17: 11540
**STAIRS, G. R.**, Chronic $\gamma$ irradiation of pitch pine-oak forest, 17: 10362

(TID-16254)
**STAMER, P.**, Radiative $\tau^+$ decay, 17: 11536
**STARCHIK, M. P.**, Polonium-210 $\alpha$ radiation for quantitative control of concentration products, 17: 10570
**STARCKJOHANN, Joachim**, Importance of hole size for sieve irradiation, 17: 10497
**STARFELT, N.**, Gamma rays from capture of fast neutrons in Ta, W, Au, Hg, and Pb, 17: 11659
**STAVISSKII, Yu. Ya.**, Scintillation counter with $CaF_2$ crystal, 17: 11044
**STEARNS, M. B.**, Abundances of Fe sites in FeSi alloys, 17: 11381
**STEBLER, A.**, Controllable ionization chambers, 17: 10967
**STEBLER, A.**, Halogen counters in dose measurements, 17: 10961
**STEBLER, A.**, Magnetic amplifiers in reactor instrumentation, 17: 10990
**STECHER, Gisela**, Results of P-32 administration in polycythemia, 17: 10272
**STEFANT, Robert**, Effect of high-altitude explosion on earth-ionosphere cavity, 17: 10828
**STEFFEN, Rolf M.**, Influence of magnetic dipole electric quadrupole interaction on angular correlations, 17: 11386
**STEIDEL, C. A.**, Liquid Bi penetration into boundaries in Ni, 17: 11241
**STEIN, R. P.**, Wet steam as reactor coolant, 17: 11965 (UNC-5008-I)
**STEINBERG, Robert**, Solid-state fission probe, 17: 10988
**STEINWEDEL, H.**, Remarks on Klein's paradox, 17: 11580
**STELZER, K.**, Neutron flux and radiation intensity at FRF, 17: 12023 (IKF-1)
**STELZER, K.**, Testing of simple model for a BWR, 17: 12024 (IKF-3)
**STEPANENKO, I. A.**, Magnetic areas in systems with helical magnetic field, 17: 11879
**STEPANOVIC, S.**, Effect of methysergide and x irradiation on rats, 17: 10418
**STEPHANOVSKI, A. M.**, Acceleration of electrons in plasma, 17: 11771 (BNL-767(p.106-15))
**STEPHEN, M. J.**, Oscillations of plasma in magnetic field, 17: 11859
**STERLING, Robert F.**, Inorganic ion-exchange resins, 17: 10710
**STERLINSKI, S.**, Determination of contaminations in P by neutron activation, 17: 10562
**STERLINSKI, Slawomir**, Spectrometric determination of trace amount of Cs in Na and K salts, 17: 10565
**STERNGLASS, E. J.**, Magnetohydrodynamic power generation, 17: 12002
**STERNHEIM, Morton M.**, Second-order effects of nuclear magnetic fields, 17: 11617 (BNL-6205)
**STEUDEL, A.**, Relative isotopic position of Os-186, 17: 11744
**STEVENS, J. I.**, Fluidized bed calcination, 17: 12045 (TID-7646(p.3-19))
**STEVES, L. H.**, Fission product and waste packaging, 17: 12040 (HW-74712)
**STEYERT, W. A.**, Binding of isolated Fe impurity atoms, 17: 11230
**STICKNEY, J. M.**, Anemia of leukemia, 17: 10341
**STIERLIN, U.**, Delbruck scattering of 17-Mev photons, 17: 11745
**STODTMEISTER, R.**, Bone marrow cell transfusions, 17: 10292 (BNL-6106)
**STODTMEISTER, R.**, Clearance of Fe-59 from plasma after total-body irradiation, 17: 10413
**STOENNER, R. W.**, Cosmic ray produced Ar-37 and Ar-39 in meteorites, 17: 11448 (BNL-6545)
**STOERING, J. P.**, Lithium-6 and $Li^7(n,2n)$ cross sections, 17: 11722
**STONE, R. G.**, Determination of Sr in tap water, 17: 10553
**STONE, Robert S.**, Renal tubular fine structure during U injury, 17: 10265
**STONEHOUSE, A. J.**, Prog. rpt. on intermetallic compounds, 1–3/62, 17: 11082 (BBC-113)
**STONEHOUSE, B. H.**, Control of gas-cooled reactors, 17: 10994
**STOOKSBERRY, R.**, Extrapolation lengths in pulsed water systems, 17: 11600 (WAPD-T-1490)
**STORK, D. H.**, $n$-$\pi$ Interaction in $\tau$-decay, 17: 11528
**STORM, M. L.**, Kinetics of low source reactor startups. I., 17: 11960 (TID-16142(Pt.I))
**STORM, M. L.**, Kinetics of low source reactor startups, 17: 11961 (TID-16142(Pt.II))
**STORMS, E. K.**, Superconductivity of $Ta_2C$, $Nb_2C$, and $V_2C$, 17: 11391
**STOVER, B. J.**, Long-term effects of Pu-239 in adult beagles, 17: 10303 (COO-226(p.95-127))
**STOVER, B. J.**, Plutonium extraction from biological material, 17: 10298 (COO-226(p.58-65))
**STOVER, Betsy J.**, Interlaboratory and interstandard comparisons of Sr-90, 17: 10299 (COO-226(p.66-70))
**STOVER, Betsy J.**, Liver injury in beagles with Pu-239, 17: 10328
**STOVER, Betsy J.**, Metabolism of Pu-239 in adult beagles, 17: 10319
**STOVER, Betsy J.**, Skeletal toxicity of Pu-239 in beagles, 17: 10320
**STRAIN, Harold H.**, Separation of metal ions from mixtures by electrochromatography, 17: 10753
**STRAKHOVICH, K. I.**, Laminar jet outflow of conducting gas with magnetic field, 17: 11352
**STRAUSS, Herbert D.**, Radiopulmonogram, 17: 10280
**STRAUSS, M.**, Generalization of Planck radiation law, 17: 11429
**STREHLER, Bernard L.**, Thermally induced aging of Drosophila, 17: 10277
**STRIKE, Thomas A.**, Effects of spleen extract treatment on hematopoietic tissues of irradiated guinea pigs. I., 17: 10369
**STRIKE, Thomas A.**, Effects of spleen extract treatment on hematopoietic tissues of irradiated guinea pigs. II., 17: 10370
**STROEMNAES, Oeistein**, Mutagenic effect of $C^{14}$- and $H^3$-labeled DNA precursors, 17: 10401
**STROHBUSCH, U.**, Construction of gas scintillation counter, 17: 11005 (IKF-5)
**STRONSKI, Ignacy**, Radiometric studies on extraction of metal ions. II., 17: 10768
**STRUB, Hermann**, Electric discharges by mixing Xe with H or He, 17: 11431
**STRUBLE, Gordon Lee**, Rotational structure in Ho-166, 17: 11729
**STUARDO, E.**, Absorption factor in KI, 17: 11622 (NP-12439)
**STUERMER, Walter**, Gas-cooled high-temperature reactor, 17: 11998 (AEC-tr-5484)
**STUETZER, Otmar M.**, Pressure analysis of conduction in liquids, 17: 11364
**SUDDATH, J. C.**, Prog. rpt. on chemical technology, 6/62, 17: 10741 (ORNL-TM-313)
**SUDDATH, J. C.**, Prog. rpt. on chemical technology, 1/61, 17: 10743 (ORNL-TM-457)
**SUESSMANN, G.**, Remarks on Klein's paradox, 17: 11580
**SUKHOTIN, A. M.**, Ion association in solutions. XI., 17: 10656
**SULLIVAN, E.**, Nonadiabatic theory of electron-H scattering. II., 17: 11389
**SULLIVAN, J. C.**, One-electron redox reactions involving destruction of $NO_2^+$ structure, 17: 10596 (TID-15793)
**SULLIVAN, R. J.**, Reprocessing studies on irradiated UC reactor fuel, 17: 10736 (NAA-SR-7511)
**SULLIVAN, W. D.**, X-radiation effect on fumarase activity, 17: 10409
**SUNAKAWA, Sigenobu**, Phonon-phonon interaction, 17: 11411
**SUNDBERG, O.**, Proton-proton scattering, 17: 11677
**SUNDKVIST, G.**, X-ray emission spectrography, 17: 10950
**SUSTA, Bohumir**, Accelerating electrons in induction accelerator, 17: 11824
**SUTIN, N.**, Oxidation of $H_2O_2$ by Ce(IV), 17: 10631
**SUURA, H.**, Positronium spectrum, 17: 11548
**SUWA, S.**, Fast ejection of proton beams from synchrotron, 17: 11801 (TID-17652)
**SUZUKI, H. K.**, Hyperossification in autogenous tibial transplants, 17: 10304 (COO-226(p.128-30))
**SVANSSON, L.**, Density measurement by $\beta$ absorption, 17: 10901 (NP-12390)
**SVEC, F.**, Leukemia induced by x-ray irradiation and treatment, 17: 10258
**SVEC, Harry J.**, Hydrolysis of rare-earth carbides, 17: 10591 (IS-499)
**SWALLOW, A. J.**, Applied radiation chemistry, 17: 10684
**SWANBERG, F., Jr.**, Radiological physics, 17: 10849 (HW-73337(p.29-76))
**SWANBERG, F., Jr.**, Urinary excretion data from Pu exposure cases, 17: 10339
**SWANSON, Bernet S.**, Vapor-liquid equilibrium in $BrF_3$–$UF_4$ system, 17: 10595 (TID-15770)
**SWANSON, C. D.**, System transfer functions by statistical methods, 17: 11947 (HW-SA-2558)
**SWANSON, R. A.**, Muon capture on C, 17: 11541
**SWARTWOUT, Robert Earl**, Speed-independent logic for control, 17: 11070 (TID-17653)
**SWEENEY, M. A.**, Prog. rpt. on radiation stability of organic fluids, 17: 11268 (TID-16999)
**SWEET, W. H.**, Neutron capture therapy of brain tumors. II., 17: 10282
**SWINSON, D. B.**, Time variations in extensive air showers, 17: 11450

**SWISHER, Joe A.**, Effects of $\alpha$ particles on polyethylene, 17: 10674 (BRL-1177)
**SYMONS, G. D.**, Evidence for 1.7-Mev level in B-9, 17: 11683
**SZKLARZ, E. G.**, Superconductivity of $Ta_2C$, $Nb_2C$, and $V_2C$, 17: 11391
**SZODA, Z.**, Reactor critical mass calculation, 17: 11463

# T

**TAI, Chien Yu**, Dynamic friction and diffusion in plasma, 17: 11891
**TAI, Wen-Hwa**, Effect of x rays on catalase in conidia of *Aspergillus niger*, 17: 10397
**TAKAHASHI, Hachiro**, Rigidity spectrum during short-term variation of cosmic rays, 17: 11455
**TAKENO, Shozo**, Energy spectrum of lattices with defects. II., 17: 11410
**TAKIZAWA, Masao**, Gamma-induced oxidation yield of Fe(II), 17: 10569
**TALMI, I.**, Shell model analysis of the level structure of Ar-41, 17: 11626 (PUC-1962-89)
**TALMI, Igal**, Coupling schemes in nuclei, 17: 11739
**TAMAS, G.**, Reactions (y,n) in C-12, O-16 and Ca-40, 17: 11672
**TANAKA, K.**, Interpretations of high-energy cross sections, 17: 11493 (TID-16216)
**TANAKA, K.**, Regge trajectory in field theory, 17: 11919
**TANDON, G. K.**, Uniformity of commercial foils, 17: 11104 (TID-16252)
**T'ANG (TANG), Ming-tao (M. D.)**, High voltage supply for scintillation counters, 17: 11022
**TAPPER, D. N.**, Prog. rpt. on fission product metabolism, 4/62–1/63, 17: 10310 (TID-17789)
**TARANI, E.**, Radiostrontium in blood and bones of rats, 17: 10347
**TARAPOV, I. E.**, Automodel problems of magnetohydrodynamics, 17: 11438
**TARAPOV, I. E.**, Magnetohydrodynamics with axial symmetry, 17: 11439
**TARASOV, E. K.**, Design considerations for proton synchrotron, 17: 11767 (BNL-767(p.75-83))
**TARPLEY, William B.**, Ultrasonic filling of cladding with ceramic powders, 17: 11162 (CEND-153(Vol.II)(p.163-94))
**TARRAGO, Xavier**, Emission of $\alpha$ particles in spallation reactions, 17: 11663
**TAUBE, M.**, Separation of Fm and Md, 17: 10735 (JINR-P-1075)
**TAUBE, Mieczyslaw**, Extraction of U and Pu chlorides, 17: 10765
**TAUXE, W. Newlon**, Anemia of leukemia, 17: 10341
**TAUXE, W. Newlon**, Localization of brain lesions with $I^{131}$-labeled polyvinylpyrrolidone, 17: 10287
**TAVKHELIDZE, A. N.**, Regge poles and perturbation theory. II., 17: 11905 (JINR-E-1095)
**TAWDE, N. R.**, Transition probabilities of BeO, 17: 10624
**TAYLOR, A. E.**, Photodecomposition of organic acids, 17: 10697
**TAYLOR, A. R., Jr.**, Thermodynamic properties of Cs chloride and iodide, 17: 10584 (BM-RI-6157)
**TAYLOR, C. J.**, Lithium-6 and $Li^7$(n,2n) cross sections, 17: 11722
**TAYLOR, D. M.**, Metabolism of Pu and Am, 17: 10325
**TAYLOR, G. N.**, Gingival ulceration induced in beagles, 17: 10296 (COO-226(p.35-49))
**TAYLOR, G. N.**, Skeletal toxicity of Pu-239 in beagles, 17: 10320
**TAYLOR, Glenn N.**, Liver injury in beagles with Pu-239, 17: 10328
**TAYLOR, H. L.**, Nuclear particle tracks in Si, 17: 11272
**TAYLOR, K. H. R.**, Field quenching in ZnS phosphors, 17: 11362
**TAYLOR, R. L.**, Problems in thermoviscoelasticity, 17: 11338 (UCRL-13059)
**TAYLOR, S.**, Radiative $\tau^+$ decay, 17: 11536
**TAYLOR, Samuel G.**, Strontium-85 in evaluation of bone metastases, 17: 10279
**TAYLOR, T. I.**, Inelastic scattering of slow neutrons, 17: 11602
**TAYLOR, W. E.**, Piping autoradiography, 17: 11004 (HW-SA-2651)
**TELLER, Edward**, Stability of molecules in Thomas-Fermi theory, 17: 11419
**TEMKIN, A.**, Nonadiabatic theory of electron-H scattering. II., 17: 11389
**TEMPLE, L. A.**, Effect of inhaled $Pu^{239}O_2$ on life span of mice, 17: 10323
**TEMPLETON, David H.**, Crystal structure of $KH_2F_3$, 17: 10608 (UCRL-10197)
**TEMPLETON, David H.**, Nuclear alignment of Ce-137m, Ce-137, Ce-139, Ce-141, and Ce-143, 17: 11705
**TENNEY, Peter N.**, Consecutive-reaction model systems, 17: 10610 (UCRL-10575)
**TENSI, Hans Maria**, Piezoelectric pulses during stress of Al–3% Mg and Al, 17: 11250
**TEODORESKU, I.**, Studying resonator cavities with high Q factor, 17: 11819
**TER HAAR, D.**, Green functions in perturbation theory. I., 17: 11357
**TER HAAR, D.**, Green functions in perturbation theory. II., 17: 11358
**TERNOPOL, A. M.**, Magnetic areas in systems with helical magnetic field, 17: 11879
**TESTERMAN, M. K.**, Prog. rpt. on electron sources and mass spectrometers, 7/1–12/31/61, 17: 10898 (N62-10115)
**TETRAULT, P. J.**, Neutron captures in U-235 and natural B, 17: 11629 (TID-15884)
**THANKAPPAN, V. K.**, Collective vibrations in Si-30, 17: 11661
**THEARD, Leslie M.**, Radiolysis of liquid methanol, 17: 10699
**THEWS, R.**, Neutron kinetics and cross sections in fast non-moderating assemblies, 17: 11598 (TID-16304)
**THIBAUDEAU, Yvian**, Strontium-85 in evaluation of bone metastases, 17: 10279
**THIBODEAU, Robert D.**, Phase equilibrium for $UO_2(NO_3)_2$–$Al(NO_3)_3$–$HNO_3$–$H_2O$, 17: 10616
**THIRRING, W.**, Linear response function for quantum mechanical system, 17: 11582
**THOMA, R. D.**, Phase equilibria in system NaF–$ThF_4$–$UF_4$, 17: 11216
**THOMAS, A.**, Prog. rpt. on detection of radiation in static and flowing liquid H, 7-9/61, 17: 10900 (NP-12363)
**THOMAS, Alexander**, Prog. rpt. on effects of radiation on liquid H medium, 17: 11264 (NP-12388)
**THOMAS, C. W.**, Radiological chemistry, 17: 10850 (HW-73337(p.77-157))
**THOMAS, G.**, Crystal structure of $\beta'$ $Cu_{0.75}Al_{0.25}$, 17: 11195 (UCRL-9536)
**THOMAS, Richard F., Jr.**, RATH mesher—program for heat conduction codes, 17: 10799 (LAMS-2809)
**THOMASSEN, K. I.**, Anomalous resistance in plasmas, 17: 11865
**THOMMEN, K.**, Centers in KCl after radiation, 17: 10711
**THOMPSON, Dudley**, Operating Brookhaven Graphite Reactor, 17: 12031
**THOMPSON, E.**, Thomson scattering from electron beam, 17: 11550
**THOMPSON, J. C., Jr.**, Prog. rpt. on fission product metabolism, 4/62–1/63, 17: 10310 (TID-17789)
**THOMPSON, J. J.**, Two-group, three-region, fully reflected cylindrical reactor program for IBM 1620, 17: 11933 (AAEC/E-101)
**THOMPSON, R. C.**, Combined toxic effects of Pu plus x-ray, 17: 10318
**THOMPSON, Roy C.**, Factors modifying absorption and retention of ingested Sr-90, 17: 10306 (HW-SA-2577)
**THOMPSON, Roy C.**, Hanford symposium on biology of transuranic elements, 5/62, 17: 10316
**THOMPSON, Samuel W., II**, Rat feeding studies with $\gamma$-irradiated foods, 17: 10350
**THOMSON, David B.**, Nuclear level densities from neutron scattering, 17: 11708
**THORAEUS, R.**, Swedish gamma radiation standard laboratory, 17: 10785
**THORN, R. J.**, Correlation of color and non-stoichiometry, 17: 11327 (TID-15799)
**THORN, R. J.**, Vaporization and thermodynamic properties of US and UOS, 17: 10598 (TID-15796)
**THORNE, R. P.**, Spectrometer for isotopic analyses, 17: 10969
**THORNE, W. L.**, Upstream boiling burnout, 17: 10794 (HW-73902(Rev.))
**THORNLEY, Margaret J.**, Radiation inactivation of *Clostridium botulinum* spores in meat, 17: 10883
**THURBER, W. C.**, Compacted powder fuel irradiation studies, 17: 11155 (CEND-153(Vol.II)(p.39-65))
**THWAITES, T. T.**, Radioactive decay of Zn-72, 17: 11723
**TIBELL, G.**, Proton-proton scattering, 17: 11677
**TICKLE, R. S.**, Prog. rpt. on 83-inch cyclotron, 10–12/62, 17: 11806 (TID-17735)
**TIETGE, J.**, Decay mode $K^+ \rightarrow \pi^+ + \pi^+ + \pi^- + \gamma$, 17: 11523
**TIKTOPOULOS, G.**, Relativistic dispersion theory, 17: 11521
**TILBURY, R. S.**, Barium-131m—a new isomer, 17: 11712
**TILLERY, M. I.**, Cascade impactor operating at low volumetric flow rates, 17: 10775 (LF-5)
**TIMIRAS, Paola S.**, Prepyriform activity after x irradiation, 17: 10373
**TIMOFEEV, A. V.**, Stability of heated plasma in magnetic field, 17: 11889
**TISINGER, Richard**, Polarization of protons from $B^{11}$(d,p)$B^{12}$, 17: 11639

(TID-17720(p.62-78))
**TOENISKOETTER, Richard H.**, Radiolytic and thermal decomposition of borazole, 17: 10700
**TOGNACCA, M. L.**, Nucleic acids in neurons of irradiated rats, 17: 10466
**TOGNACCA, M. L.**, Picture from irradiation of brain in rats, 17: 10459
**TOLMACHEV, A. M.**, Isotopic exchange of O, 17: 10634
**TOLOK, V. T.**, Magnetic areas in systems with helical magnetic field, 17: 11879
**TOLSTOV, K. D.**, Estimate of virtual number of events, 17: 11475 (JINR-P-1085)
**TONANI, F.**, Beryllium determination in granite diorites, 17: 10827
**TONDINALLI, L.**, Proton-recoil counter exposed to neutron source, 17: 11002 (CNEN-158)
**TONG, L. S.**, Mixing in flow parallel to rod bundles having square lattice, 17: 10804 (WCAP-1607)
**TONNA, E. A.**, Leukemogenic effect of whole-body $\gamma$ irradiation, 17: 10354 (BNL-6105)
**TOPA, A.**, Electrode for (n,n) and (n,$\gamma$) radioactive logging, 17: 10836
**TOPCHIEV, A. V.**, Radiolysis of hydrocarbon, 17: 10722
**TOPEK, Nathan H.**, Irradiation changes in vaginal cytology, 17: 10372
**TORP, B. A.**, Reactions of Nb(V) halides with pyridine, 17: 10500 (IS-385)
**TOUSCHEK, B.**, "AdA" accumulator ring for electrons and positrons, 17: 11820
**TOWNS, Donald L.**, Deuterium exchange of aryl 2-octyl sulfones, 17: 10670
**TRAIL, C. C.**, Analysis of $\gamma$ spectra, 17: 11444
**TRAIL, C. C.**, Lifetimes of radioactive sources, 17: 11628 (TID-15849)
**TREACY, P. B.**, Evidence for 1.7-Mev level in B-9, 17: 11683
**TREILLE, Daniel**, Elastic electron-deuteron scattering and neutron EM structure, 17: 11505
**TRETYAKOVA, Ch. (C.) A.**, Energetic particle interactions with atomic nuclei at mountain altitudes, 17: 11454
**TRET'YAKOVA, S. P.**, Radiography of spontaneous nuclear fission, 17: 10535 (JINR-P-1118)
**TROUBETZKOY, E. S.**, Description of SORTIE I code, 17: 11591 (NP-12370)
**TRUBEY, D. K.**, IBM-7090 subroutine package for making logarithmic and semilogarithmic graphs, 17: 11067 (ORNL-TM-430)
**TRULIO, J. G.**, Classical systems of charged particles, 17: 11497 (UCRL-6450-T(Rev.I))
**TSARENKO, A. P.**, Interaction time between beam and target, 17: 11813
**TSESSARSKAYA, G. P.**, Myeloid cells in acute radiation sickness, 17: 10495
**TSITOVICH, A. P.**, Delay system for neutron time-of-flight spectroscopy, 17: 11036
**TSOU, Chu-Lien**, Discharge in spark chamber, 17: 11038
**TSU, T. C.**, Magnetohydrodynamic power generation, 17: 12002
**TSUJII (TSUJI), Junro**, Measurement of concentration of pulverized coal in pneumatic conveyors by $\beta$ transmission, 17: 10881 (AEC-tr-5581)
**TSUNETO, Toshihiko**, Dirty superconductors, 17: 11418
**TSUNETO, Toshihiko**, Effects of impurity scattering on excitons, 17: 11412
**TUAN, Sun Fu**, Singularity in KN scattering, 17: 11514
**TUCKER, G. E. G.**, Composition of X phase in Al–Mn–Ni, 17: 11249
**TUCKER, G. E., Jr.**, Portable radiac equipment at Sandia, 17: 11007 (TID-15765)
**TUCKFIELD, R. G.**, Separation of emission light during plasma injection, 17: 11854
**TUNNICLIFFE, P. R.**, Lattice parameters for NPD and CANDU fuel elements in $D_2O$, 17: 11939 (CRL-75)
**TURCHINETZ, W.**, Polarization of neutrons from photodisintegration of D, 17: 11551
**TURKIEWICZ, Jan**, Fast neutrons elastically scattered on Ca, 17: 11593 (PAN-354/I-A)
**TURKOWA, Bogusława**, Determination of Pb in ore, 17: 10564
**TURNER, Cyril H. M.**, Mirror-symmetry in beam transport systems, 17: 11802 (TID-17661)
**TURNER, Kenneth Clyde**, Velocity-dependent interaction between natural clocks and distant matter, 17: 11325 (PUC-1962-68)
**TURNER, R. E.**, Quasi-classical approximation in neutron scattering, 17: 11606
**TURNER, R. F.**, Helium inleakage through fuel elements, 17: 11189 (GAMD-2638)
**TUTHILL, E. J.**, Continuous phosphate glass process, 17: 12048 (TID-7646(p.43-51))
**TUTSCHULTE, Theodore C.**, Oceanographic literature of Santa Barbara channel area, 17: 10826 (TID-17722)
**TYAPKIN, A. A.**, Discharge in spark chamber, 17: 11038
**TZARA, C.**, Reactions (y,n) in C-12, O-16 and Ca-40, 17: 11672
**TZOAR, Narkis**, Absorption of waves in plasmas, 17: 11864

# U

**UCHIDA, Irene A.**, Association between maternal radiation and mongolism, 17: 10436
**UCHIDA, Irene A.**, Effect of age and radiation on rate of non-disjunction in Drosophila, 17: 10400
**UDOVICHENKO, Yu. K.**, Penetration of magnetic field into plasma, 17: 11885
**UHDE, F.**, Production of $D_2O$ by electrolysis, 17: 11056 (CEA-tr-A-1159)
**UHLMANN, W.**, Bibliography on radiation effects on U-based fuel materials, 17: 11269 (VDIT-16(2.4))
**ULLAH, Nazakat**, Coupling of MHD to EM waves at plasma discontinuity. I. 17: 11850
**ULLBERG, Sven**, Distribution of Pu in mice, 17: 10260
**ULMER, R.**, Electron-H atom collisions, 17: 11366
**UMAKANTHA, N.**, Scattering of cold neutrons by BeO, 17: 11671
**UMEMURA, Isao**, Model for physical nucleon, 17: 11558
**UNRUH, C. M.**, Emergency planning for radiation accident, 17: 10855 (HW-SA-2609)
**UPADHYAYA, G. S.**, Crystal structure of hydrides, 17: 11237
**UPSON, U. L.**, Scintillating glasses for $\alpha$ counting, 17: 11003 (HW-72512)
**UPTON, A. C.**, Modification of foreign spleen reaction, 17: 10434
**URBANSKI, T. S.**, Extraction of U(VI) and Fe(III), 17: 10766
**UVAROV, O. V.**, Physiochemical constants of heavy-oxygen $H_2O$, 17: 10657
**UVAROV, V. A.**, Electronic systems for proton synchrotron, 17: 11763 (BNL-767(p.32-47))

# V

**VACEK, K.**, Luminescence of AgCl crystals, 17: 10712
**VALENTINE, R. F.**, Criticality predictions of PWR-2 design, 17: 11994 (WAPD-T-1370)
**VALENTINE, R. F.**, Power distribution in PWR-2 mockup, 17: 11993 (WAPD-T-1369(Rev.))
**VAL REUTER, Mary Del**, Induced changes in female germ cells of Drosophila. VII., 17: 10415
**VAL'TER, A. K.**, Scattering of 6.9-Mev protons by Cr and Zn, 17: 11656
**VAL'TSEV, V. K.**, Precipitation of certain elements from fused $NH_4NO_3$, 17: 10621
**VANDENPLAS, P. E.**, Scattering behavior of a cold plasma cylinder, 17: 11856
**VAN DER MAAS, Gerard**, Charge measurement of U-235, 17: 11760
**VAN DER WOUDE, F.**, E2/M1 mixing ratio of 123-kev transition in Fe-57, 17: 11701
**VAN DER ZIEL, A.**, Noise properties of gas discharges. I., 17: 11829 (ASD-TR-61-179(Vol.I))
**VAN ELST, H. C.**, Prog. rpt. on ductile-brittle transition temperature on steel, 7–9/62, 17: 11187 (EURAEC-447)
**VAN HIEU, Nguyen**, Regge poles and perturbation theory. II., 17: 11905 (JINR-E-1095)
**VAN SOESTBERGEN, A. A.**, Irradiation experiments with *Pseudomonas aeruginosa*, 17: 10419
**VARAGIC, V.**, Effect of methysergide and x irradiation on rats, 17: 10418
**VARDE, Eva**, Concentration distribution of isotopic mixtures, 17: 11059
**VARGA, Louis P.**, Fluoride complexes of Hf, 17: 10600 (TID-15939)
**VARICAK, M.**, Measuring x-ray energy, 17: 10975
**VARSAVSKY, Carlos M.**, Prog. rpt. on photo processes, 9–11/62, 17: 10681 (TID-17743)
**VASILENKO, A. T.**, Hydrogen–D bubble chamber in magnetic field, 17: 10930
**VASIL'EV, A. A.**, Analog for studying particles in synchrotron, 17: 11774 (BNL-767(p.161-71))
**VASIL'EV (VASIL'JEV), A. A.**, Automatic closed orbit control, 17: 11811

(NP-tr-932)
**VASIL'EV, A. A.**, Cyclic accelerators for high energies, 17: 11769 (BNL-767(p.91-9))
**VASIL'EV, A. A.**, Electronic systems for proton synchrotron, 17: 11763 (BNL-767(p.32-47))
**VAUGHAN, Janet**, Possible binding agent for Y, Am, and Pu, 17: 10332
**VAUGHAN, R. I.**, Aspects of stability studies, 17: 10984
**VAVRINEC, E.**, Luminescence of AgCl crystals, 17: 10712
**VECCHIONI, R.**, Radiation effects on collagens. III., 17: 10465
**VEIL, E. I.**, Fabrication of $UO_2$ elements by 'vibswage' process, 17: 11150 (CEND-153(Vol.I)(p.137-47))
**VEKSHINA, N. V.**, Boron carbides in C reduction of rare earth mixtures with B, 17: 10662
**VELDE, Harold**, Electrometer amplifier, 17: 11016
**VELDRE, V.**, Ionization of H atom close to threshold, 17: 10707
**VELDRE, V. Ya.**, Distortion of incident s-wave in ionization of H by electrons, 17: 11359
**VENABLES, J. A.**, Liquid He cooled tilting stage for electron microscope, 17: 10914 (TID-17744)
**VENIKOV, N. I.**, Ion bunch duration and recurrence of bunch in cyclotron, 17: 11779 (BNL-767(p.278-87))
**VENIKOV, N. I.**, Ion beam energy spread, 17: 11780 (BNL-767(p.288-92))
**VENKATASETTY, H. V.**, Non-aqueous conductance data, 17: 10504 (NYO-9696)
**VENKATESWARLU, K. S.**, CIR team solved corrosion, deposition problems, 17: 11136
**VENUGOPALAN, M.**, Separation of H isotopes on activated alumina, 17: 11057
**VERGROESEN, A. J.**, Protection of cells against ionizing radiation. I., 17: 10491
**VERMEULEN, Theodore**, Consecutive-reaction model systems, 17: 10610 (UCRL-10575)
**VERTEBNI, V. P.**, Neutron monochromator consisting of disks, 17: 10937
**VERTEBNI, V. P.**, Pulse form and transmission function of two-rotor neutron chopper. I., 17: 10938
**VESSELINOVITCH, D.**, Blood vessels of irradiated rats, 17: 10485 (NP-12251(p.99-113))
**VIDEIRA, A. L. L.**, Production and spin of K* resonance, 17: 11487 (NP-12488)
**VIENBOECK, F. P.**, Electromagnetic isotope separator of SGAE, 17: 10923
**VIGNUDELLI, A. Quareni**, Decay mode $K^+ \to \pi^+ + \pi^+ + \pi^- + \gamma$, 17: 11523
**VILESOV, F. I.**, Photoionization and application in mass spectroscopy, 17: 10567
**VINCENT, R. C.**, Instrument maintenance at Calder Hall, 17: 10997
**VINOGRADOV, A. P.**, Escape mechanism of radiogenic gases, 17: 10829
**VINOGRADOV, N. I.**, Diffusion of charged particles in dense plasma, 17: 11880
**VISKANTA, R.**, Heat transfer in Couette flow of radiating fluid with viscous dissipation, 17: 10802 (TID-17664)
**VIVIANI, C.**, Modifications of neurons of Gasser ganglion, 17: 10461
**VLADIMIROV, V. V.**, Pipe-pinch stability, 17: 11882
**VLADIMIRSKII (VLADIMIRSKIJ), V. V.**, Design considerations for proton synchrotron, 17: 11767 (BNL-767(p.75-83))
**VLADIMIRSKII (VLADIMIRSKIJ), V. V.**, Experiment with colliding beams without storage, 17: 11775 (BNL-767(p.172-6))
**VLADIMIRSKII (VLADIMIRSKIJ), V. V.**, Magnetic measurements in accelerator, 17: 11762 (BNL-767(p.1-31))
**VLADIMIRSKII (VLADIMIRSKIJ), V. V.**, Parameters of 50-70 Bev proton synchrotron, 17: 11765 (BNL-767(p.64-6))
**VLASENKO, N. A.**, Impurities in formation of luminescence centers in ZnS–Cu, 17: 11228
**VLASOV, V. G.**, Reduction of $UO_2$ with ammonia, 17: 10725
**VLASOV, V. G.**, Uranium oxide reduction with decomposed ammonia, 17: 10726
**VODOP'YANOV, F. A.**, Control system for beam in synchrotron, 17: 11764 (BNL-767(p.48-63))
**VODOP'YANOV, F. A.**, Electronic systems for proton synchrotron, 17: 11763 (BNL-767(p.32-47))
**VOGEL, Howard H., Jr.**, Thymic lymphoma incidence and longevity of female mice irradiated with neutrons or $\gamma$ rays, 17: 10360 (TID-15850)
**VOGLER, S.**, Contamination and decontamination studies related to BWR, 17: 11959 (TID-15779)
**VOGT, Erich**, Low-energy nuclear reactions, 17: 11740
**VOGT, G. S.**, Toxicity of inhaled Pu in dogs, 17: 10322
**VOGT, R. H.**, Spectrum from modified split reactor core, 17: 12030
**VOGT-KOEHNE, Lore**, Radiation effects on *Paramecium aurelia* growth, 17: 10408
**VOIGT, Adolf F.**, Radiation dose I scavenger effects recoil C-11 reactions in cyclohexane, 17: 10701
**VOIGT, Adolf F.**, Reaction mechanisms for (γ,n) activated $C^{11}$ reactions in liquid cyclohexane, 17: 10675 (IS-425)
**VOJTA, G.**, Gibbs statistics of isotope systems, 17: 10655
**VOJTA, Gunter**, Quantum statistic of molecules, 17: 11343
**VOLKOVA, M. A.**, Distribution of radioactive Y salts in animals, 17: 10443
**VOLKOVA, R. M.**, Thermodiffusion in W–Be system, 17: 11214
**VON HALLE, Edward**, Thermal diffusion column performance, 17: 11051 (TID-15343)
**VON KOCH, Helge**, Conference on instruments and measurements, 17: 10941
**VON KOCH, Helge**, Conference on instruments and measurements, 17: 10956
**VON UBISCH, Hans**, Mass spectrometry, 17: 10942
**VOROZHTSOV, B. I.**, Dielectric losses induced in polymers by radiation, 17: 11278
**VOROZHTSOV, B. I.**, Gamma effects on insulating materials. II., 17: 11277
**VORSPRACH, F.**, Handling devices in γ radioscopy, 17: 10818
**VOS, O.**, Homologous radiation chimeras, 17: 10473
**VOS, O.**, Immunological tolerance in radiation chimeras, 17: 10474
**VOS, O.**, Protection of cells against ionizing radiation. I., 17: 10491
**VOS, O.**, Protection of tissue-culture cells against ionizing radiation. II., 17: 10493
**VUL'FSON, N. S.**, Mass-spectroscopic study of carbohydrates, 17: 10557
**VYALOV, G. N.**, Production of magnetic field by current, 17: 11440
**VYLKOV, N.**, Response of semiconductor detectors, 17: 11045

# W

**WABER, J. T.**, Indirect relativistic effect on 5f electrons in U, 17: 11395
**WAGNER, E. R.**, Control rod worth for EGCR, 17: 11958 (TID-11601)
**WAHL, R.**, Multidimensional analysers, 17: 10976
**WAHLGREN, M. A.**, Determination of Ge in mineral specimens, 17: 10574
**WAHLGREN, Morris**, Separation of actinides with nitric acid–methanol and EDTA, 17: 10771
**WAINSWTEIN, L. A.**, Boundary problems for hollow cylinder. II., 17: 11432
**WAINSWTEIN, L. A.**, Boundary problems for hollow cylinder. III., 17: 11433
**WAKITA, Hitoshi**, Quantum theory of interacting fields, 17: 11923
**WALCZAK, Tadeusz**, Fast-slow coincidence circuit with time to pulse-height converter, 17: 11033
**WALDSCHMIDT, Marianne**, Comparison of $S^{35}$-sulfide and $S^{35}$-sulfate in albumin, 17: 10312 (AEC-tr-5600)
**WALKER, C. S.**, Computer calculations for loss-of-power in EGCR, 17: 11987 (ORNL-TM-476)
**WALKER, R. M.**, Uranium concentrations in natural crystals, 17: 10555
**WALKER, W. H.**, Close packed lattices in $H_2O$ and $D_2O$—spectrum, 17: 11940 (CRRP-895)
**WALL, Gaylord**, Bubble chamber track-centering device, 17: 11000 (BNL-6094)
**WALL, John A.**, Irradiation changes in vaginal cytology, 17: 10372
**WALL, N. S.**, Inelastic α-particle excitation, 17: 11682
**WALLACE, F. B.**, Prog. rpt. on SPUR power program, 12/13/62, 17: 12036 (SY-5396-R3)
**WALLACE, W. E.**, Magnetic characteristics of hydrogenated Ho, 17: 10599 (TID-15935)
**WALLACE, W. E.**, Magnetic characteristics of Gd, Tb and Y hydrides, 17: 11329 (TID-15934)
**WALLACH, K. E.**, Relative isotopic position of Os-186, 17: 11744
**WALLIS, G. B.**, Influence of liquid viscosity on flooding in vertical tube, 17: 10788 (62GL132)
**WALSH, Lawrence**, Irradiation of cerebral astrocytomata, 17: 10438
**WALTERS, G. K.**, Large He-3 nuclear polarization, 17: 11730
**WALTHER, H.**, Relative isotopic position of Os-186, 17: 11744
**WALTON, A. J.**, Acidity meter for uranyl nitrate solutions, 17: 10972
**WANG, I-T.**, Structure of $2^+$ states in even-even nuclei, 17: 11698

**WANG, Tung-seng,** Separation of Fm and Md, 17: 10735 (JINR-P-1075)
**WARBURTON, E. K.,** Parity of 2.13-Mev first excited state of B-11, 17: 11707
**WARKE, W. R.,** Electron microscopic fractography, 17: 11083 (DMIC-Memo-161)
**WARREN, E.,** Perturbation of electron density by Alouette satellite, 17: 11451
**WARREN, Shields,** Radiation effects on lung, 17: 10476
**WARSHAW, S.,** Rapid beam ejector at Cosmotron, 17: 11785 (BNL-6678)
**WASE, Arthur,** Absorption and excretion of Hg-203 mercaptomerin Na, 17: 10345
**WASIF, Saad,** Kinetic energy release in deuteron fission of U-238, 17: 11646 (UCRL-10193)
**WASSERMAN, R. H.,** Prog. rpt. on fission product metabolism, 4/62–1/63, 17: 10310 (TID-17789)
**WASSON, M. McN.,** Fluorescent decay of anthracene, 17: 10671 (AERE-M-1153)
**WATERS, E. D.,** Heat transfer for out-of-reactor cooling of PRTR fuel elements, 17: 10793 (HW-72097(Rev.))
**WATERS, E. D.,** Upstream boiling burnout, 17: 10794 (HW-73902(Rev.))
**WATERS, J. R.,** Muon capture on C, 17: 11541
**WATMOUGH, T.,** Prog. rpt. on 2400°F forging die system, 9–12/62, 17: 11081 (ASD-TR-7-886(Vol. VII))
**WATSON, C. D.,** Prog. rpt. on chemical technology, 6/62, 17: 10741 (ORNL-TM-313)
**WATSON, C. D.,** Prog. rpt. on chemical technology, 1/61, 17: 10743 (ORNL-TM-457)
**WATSON, E. C.,** Hazards of shipping radionuclides, 17: 10853 (HW-SA-2518)
**WATTENBERG, A.,** Rapid beam ejector at Cosmotron, 17: 11785 (BNL-6678)
**WATTS, H. V.,** Final rpt. on neutron interactions in matter, 17: 10880 (ARF-1164-27)
**WATTS, T. L.,** Heavy-ion detection system, 17: 11008 (TID-16174)
**WATTS, T. L.,** Thin films for measurement of charged-particle ranges, 17: 10911 (TID-16251)
**WATTS, T. L.,** Uniformity of commercial foils, 17: 11104 (TID-16252)
**WEAVER, C. F.,** Phase equilibria in system NaF–$ThF_4$–$UF_4$, 17: 11216
**WEAVER, L. D.,** Polarization of optical radiation by electron impact on He, 17: 11396
**WEAVER, Lynn E.,** Boiling reactor noise, 17: 12008
**WEBER, Gunster,** Paramagnetic relaxation of chlorides of Nd, Gd, Dy, and Er from 1.1 to 4.2°K, 17: 10652
**WEBER, J.,** Neutron kinetics and cross sections in fast non-moderating assemblies, 17: 11598 (TID-16304)
**WEHMEYER, David B.,** Analysis of $H_2O$-moderated $UO_2$ and $ThO_2$ lattices, 17: 11938 (BAW-1257)
**WEIDENBAUM, B.,** Prog. rpt. on high-performance $UO_2$ program, 1–3/62, 17: 11086 (GEAP-3771-4)
**WEINSENFELD, C. H.,** Average energy of sputtered metal atoms, 17: 11374
**WEINBERG, Alvin M.,** Theory and technology of chain reactors, 17: 11975
**WEINREICH, Marcel I.,** Circuits of two-condition, flip-flop stages with complementary transistors, 17: 10921 (SCL-T-460)
**WEISMAN, Joel,** Power requirements for slurry transport, 17: 10809
**WEISS, Alwich,** Nuclear quadrupole coupling constants of Na-23, 17: 10646
**WEISS, J. J.,** Radiation-induced crosslinking of polymers, 17: 11279
**WEISSENBERG, A. O.,** Absorption of mesons in emulsion nuclei, 17: 11679
**WELL, Dale E.,** Oceanographic literature of Santa Barbara channel area, 17: 10826 (TID-17722)
**WELTY, James R.,** Thermodynamic properties of Y and Fe pentacarbonyl, 17: 10580 (BM-RI-6155)
**WENDENBURG, J.,** Gamma radiolysis of chlorobenzene, 17: 10716
**WENESER, J.,** Penetration effects in magnetic-dipole L-shell internal conversion, 17: 11618 (BNL-6647)
**WENTZEL, Gregor,** Hyperons with and without doublet symmetry. II., 17: 11532
**WENZEL, Albert W.,** Separation and determination of soluble Si in Pu, 17: 10548
**WERGELAND, H.,** Green functions in perturbation theory. II., 17: 11358
**WERTH, Glenn C.,** Calculating amplitude of refraction arrival, 17: 11337 (UCRL-7146)
**WEST, C. M.,** Statistics in health physics, 17: 10869 (Y-KB-7)
**WEST, J. E.,** Toxicity of inhaled Pu in dogs, 17: 10322
**WEST, W. W.,** Prog. rpt. on radiation stability of organic fluids, 17: 11268 (TID-16999)
**WESTERMARK, T.,** Moisture determination by beta-ray transmission, 17: 10981
**WESTERMARK, Torbjoern,** Isotopes in physical chemistry, 17: 10643
**WESTERN, G. T.,** Energy and angular distribution experiment. I., 17: 11900 (NARF-62-16T)
**WESTIN, R.,** Paramagnetism of dissolved Mn in $\alpha$ and $\beta$ brasses, 17: 11297 (AE-95)
**WETHERN, R. J.,** Heat and momentum transfer in laminar flow, 17: 11842
**WEYZEN, W. W. H.,** Homologous radiation chimeras, 17: 10473
**WEYZEN, W. W. H.,** Immunological tolerance in radiation chimeras, 17: 10474
**WHATLEY, M. E.,** Prog. rpt. on chemical technology, 6/62, 17: 10741 (ORNL-TM-313)
**WHATLEY, M. E.,** Prog. rpt. on chemical technology, 1/61, 17: 10743 (ORNL-TM-457)
**WHEATLEY, J. C.,** Properties of He-3, 17: 10603 (TID-17721)
**WHEELER, John Archibald,** General relativity and differential geometry, 17: 11930
**WHEELER, R. G.,** Measurement of cylindrical shapes, 17: 11259 (HW-71521(Rev.))
**WHITE, Clayton S.,** Nuclear bomb effects computer, 17: 10845 (CEX-62.2)
**WHITE, F. A.,** Cascade mass spectrometer, 17: 10909 (TID-15951)
**WHITE, F. A.,** Pulsed electrostatic analyzer for ion energy determinations, 17: 11010 (TID-16311)
**WHITE, F. A.,** 360° Tandem mass spectrometer, 17: 10912 (TID-16312)
**WHITE, J. A.,** Energy levels of rare earth ions, 17: 10636
**WHITNEY, David C.,** Effects of ion hydration in solvent extraction, 17: 10751 (UCRL-10505)
**WHITNEY, David C.,** Extraction of acids by basic organic solvents. I., 17: 10750 (UCRL-10063)
**WIANT, D. E.,** Radiation effects on wheat, 17: 10374
**WICHMANN, P.,** Determining TBP content of kerosene-based extraction, 17: 10536 (NP-12398)
**WICKS, Charles E.,** Thermodynamic properties of Y and Fe pentacarbonyl, 17: 10580 (BM-RI-6155)
**WIDMER, Hans,** Combination of gas chromatograph with mass spectrograph, 17: 10558
**WIEN, K.,** Decay of Cl-38 isomers, 17: 11747
**WIESE, W. L.,** Profiles of Balmer lines in H plasma, 17: 11860
**WIGGINS, A. D.,** Effect of inhaled $Pu^{239}O_2$ on life span of mice, 17: 10323
**WIGHTMAN, A. S.,** Localizability of quantum mechanical systems, 17: 11929
**WIJNEN, M. H. J.,** Formation of benzene in radiolysis of acetylene, 17: 10698
**WILCZNSKI, J.,** Scattering of deuterons on Al-27 nuclei, 17: 11625 (PAN-204)
**WILDER, D. R.,** Progress in sintering, 17: 11090 (IS-460)
**WILKENS, M.,** Depolarization and scattering of neutrons by ferromagnetic crystals, 17: 11610
**WILKERSON, T. D.,** Ion energy analyzer for plasma measurements, 17: 10897 (NATT-121)
**WILKINS, Coleridge A.,** Slowing down of neutrons, 17: 11603
**WILKINS, S. R.,** Portable measuring instruments, 17: 10968
**WILKINSON, D. H.,** Helium-3 reactions on B-11 and N-14, 17: 11721
**WILKINSON, D. H.,** Parity of 2.13-Mev first excited state of B-11, 17: 11707
**WILLARD, D. H.,** Retention, translocation, and excretion of inhaled $Pu^{239}O_2$, 17: 10321
**WILLARD, D. H.,** Toxicity of inhaled Pu in dogs, 17: 10322
**WILLEN, Erick,** Neutron spectroscopy, 17: 11638 (TID-17720(p.38-61))
**WILLHAM, R. L.,** Effect of paternal irradiation on swine, 17: 10414
**WILLIAMS, B. F.,** Nuclear quadrupole interaction of Sb-121 and Sb-123, 17: 11385
**WILLIAMS, Grady,** Distribution and excretion of radioactive rare earth compounds, 17: 10308 (TID-17542)
**WILLIAMSEN, H. R.,** Setting neutron current, 17: 11599 (WAPD-T-1457)
**WILLIAMSON, M. A.,** Lithium-6 and $Li^6(n,2n)$ cross sections, 17: 11722
**WILLIAMSON, Margaret,** Possible binding agent for Y, Am, and Pu, 17: 10332

**WILLIS, C.**, Radiolysis of ferro- and ferri-cyanide solutions, 17: 10692
**WILSON, A. M.**, Spectrophotometric determination of Co, 17: 10540 (TID-17745)
**WILSON, Arthur M.**, Solvent extraction of inorganic ions with surface-active agents, 17: 10749 (TID-17746)
**WILSON, B. G.**, Time variations in extensive air showers, 17: 11450
**WILSON, Richard**, Slightly inelastic p-d scattering, 17: 11540
**WIMBER, Doris R.**, Cell population studies on intestine of irradiated rats, 17: 10355 (BNL-6113)
**WINCEL, H.**, Ethyl halogenide dissociations in G-M tubes, 17: 11025
**WINCKLER, R.**, Density measurement by $\beta$ absorption, 17: 10901 (NP-12390)
**WINSHIP, Theodore**, Thyroid cancer study in children, 17: 10262
**WINSLOW, G. H.**, Correlation of color and non-stoichiometry, 17: 11327 (TID-15759)
**WINTER, H.**, Stability of metal bonding adhesives, 17: 11175
**WINTER, J. M.**, NMR modes in magnetic material. I., 17: 11379
**WINTER, R. G.**, Properties of F-20, 17: 11694
**WIRSING, E.**, Uranium recovery from unirradiated fuel elements, 17: 10728 (BNL-6148)
**WIRSING, E.**, Volatility reprocessing of reactor fuels, 17: 10730 (BNL-6195)
**WIRTZ, K.**, Development of fast breeder reactor, 17: 12021
**WISSLER, R. W.**, Blood vessels of irradiated rats, 17: 10485 (NP-12251 (p.99-113))
**WITCOFSKI, Richard L.**, Survival time after whole-body radiation, 17: 10467
**WITT, Norman F.**, Rat feeding studies with $\gamma$-irradiated foods, 17: 10350
**WITTMER, G.**, Radioinduced polygenic mutability in *N. tabacum*, 17: 10387
**WLODARSKI, Andrzej**, Effect of electrostatic phenomena on fluidization process, 17: 11202 (AEC-tr-5621)
**WOLF, Clarence J.**, Radiolytic and thermal decomposition of borazole, 17: 10700
**WOLF, N. S.**, Mouse embryo factors in post-irradiation restoration, 17: 10421
**WOLFE, Gene**, Gamma-induced expansion of LiF, 17: 11266 (TID-15896)
**WOLFE, Robert L.**, Prog. rpt. on nuclear reactions, 1/9/62–1/9/63, 17: 11634 (TID-17696)
**WOLLENBERG, Harold A., Jr.**, Cement for low-background counting facility, 17: 11903 (UCRL-10475)
**WOLSKA-WITEROWA, Maria**, Synthesis of $C^{14}$-labeled methylamine hydrochloride, 17: 10517 (PAN-336/XIII)
**WONG, D. Y.**, Modification of model for $\pi^- + p \rightarrow \pi^- + \pi^+ + n$, 17: 11535
**WONG, Jacob Y. M.**, Magnet systems design, 17: 11790 (PPAD-459F)
**WOO, Ching-Hung**, Neutrino pair emission by stellar plasma, 17: 11446
**WOODSUM, H.**, Supercritical water reactor shield, 17: 11988 (PWAC-100)
**WOODWARD, C. E.**, Measuring electron-ionization cross sections, 17: 11319 (NP-12358)
**WORTH, William S.**, Rat feeding studies with $\gamma$-irradiated rats, 17: 10350
**WRAIGHT, L. A.**, Creep properties of Mg–Cd alloy, 17: 11179 (AERE-M-1149)
**WRIGHT, Harvel**, Instabilities in plasma-beam system in magnetic field, 17: 11863
**WRIGHT, J. H.**, Magnetohydrodynamic power generation, 17: 12002
**WRIGHT, R. L.**, Neutron capture therapy of brain tumors. II., 17: 10282
**WROBLEWSKA, Maria**, Determining $D_2O$ in $H_2O$, 17: 10566
**WU, Tai Tsun**, Quantization of the EM field, 17: 11911
**WUCKEL, L.**, Radiation stability of ion exchangers, 17: 11276
**WUNDERLICH, F.**, Decay of Cl-38 isomers, 17: 11747
**WUNDERLICH, L. H.**, HAFMAT—steady-state flow distribution program, 17: 10798 (KAPL-M-LXW-1)
**WUNDT, Hermann**, Gas-cooled high-temperature reactor, 17: 11998 (AEC-tr-5484)

## X

**XUONG, Nguyen-Huu**, Four-pion resonance and decay modes of $\rho$ and $\omega$ mesons, 17: 11499 (UCRL-10089(Rev.))

## Y

**YABLOKOV, B. N.**, Symmetrical ring phasotron, 17: 11776 (BNL-767 (p.181-97))
**YAFFE, L.**, Barium-131m—a new isomer, 17: 11712
**YAFFE, L.**, Decay of Ba-131m, 17: 11713
**YAFFE, L.**, Excitation and charge dispersion in proton fission of U, 17: 11725
**YAKIMENKO, V. L.**, Magnetic sound in plasma with thermal motion. I., 17: 11878
**YAKIMOVICH, K. A.**, Tungsten enthalpy from 350°C to 2000°C, 17: 11207
**YAKOVENKO, V. M.**, Energy losses of charged particles above plasma in vacuum, 17: 11886
**YALE, Seymour H.**, Radiation hygiene status in dental offices, 17: 10871
**YAMADA, M.**, Structure of $2^+$ states in even-even nuclei, 17: 11698
**YAMAGUCHI, Yoshio**, $\Xi^-$ capture at rest by H, 17: 11567
**YAMAMOTO, Hiroshi**, Model of weak interaction, 17: 11562
**YAMAMOTO, Y. L.**, Late neurological effect following acute irradiation, 17: 10356 (BNL-6546)
**YAMAMOTO, Yasukazu Lucas**, RBE of thermal neutrons and heavy particles from $B^{10}(n,\alpha)Li^7$, 17: 10475
**YAMAMURA, Masatoshi**, Collective motion in even-even deformed nuclei, 17: 11732
**YANG, C. N.**, Quantum phases of liquid He, 17: 11423
**YAO, Y. L.**, Intermediate phases in transition-metal alloys, 17: 11235
**YARINSKY, Allen**, Mortality of x-irradiated mice infected with *T. spiralis*, 17: 10431
**YARINSKY, Allen**, Radiation effects on immunity of mice to infection with *T. spiralis*, 17: 10424
**YARKOVOI, O. I.**, Stationary state of system of charged particles, 17: 11887
**YATES, W. W.**, Treatment of mosquito larvae with P-32, 17: 10423
**YATSIV, S.**, Fluorescence spectra of transition elements, 17: 11368
**YAZEVA, V. G.**, Oscillations excited in plasma by an electron beam, 17: 11871
**YEMEL'YANOVA, A. P.**, Resistance to irradiation of silicate-filled rubber vulcanizates, 17: 11286
**YENNIE, D. R.**, Positronium spectrum, 17: 11548
**YOKO-O, Yoshimatsu**, Phonon-phonon interaction, 17: 11411
**YOKOOJI (YOKOOGI), Makoto**, Measurement of concentration of pulverized coal in pneumatic conveyors by $\beta$ transmission, 17: 10881 (AEC-tr-5581)
**YOKOSAWA, A.**, Fast ejection of proton beams from synchrotron, 17: 11801 (TID-17652)
**YOSHIZAWA, Yasukazu**, Quadrupole vibration in spherical nuclei, 17: 11685
**YOUNG, Harold D.**, EGCR operational refueling, 17: 12007
**YUAN, Jung-Fang**, Hydrogen–D bubble chamber in magnetic field, 17: 10930
**YUZEFOVICH, A. A.**, Strontium-90 in Atlantic surface waters, 17: 10835

## Z

**ZAGANESCU, M.**, Riemann-Cauchy relationships in $\pi$-N interaction, 17: 11571
**ZAGORITES, H. A.**, Scintillation system for inspection of W billets, 17: 10816 (USNRDL-TR-602)
**ZAGURY, N.**, Production and spin of K* resonance, 17: 11487 (NP-12488)
**ZAIENTS, S. L.**, Parallel work of controlled spark gaps, 17: 11048
**ZAKER, T. A.**, Prog. rpt. on reactor containment, 8/60–1/61, 17: 11937 (ARF-4132-16)
**ZALKIN, Allen**, Crystal structure of $KH_2F_3$, 17: 10608 (UCRL-10197)
**ZAMFIRESKU, I.**, Determination of neutron flux distribution, 17: 11608
**ZAMICK, Larry**, Impulse approximation and distorted waves, 17: 11731
**ZANCHI, F.**, Proton-recoil counter exposed to neutron source, 17: 11002 (CNEN-158)
**ZANKL, G.**, Stress-strain curve of Ni, 17: 11234
**ZANNETI, R.**, $\beta$-absorption and glass transitions in polymers, 17: 11282
**ZANNONE, L.**, X-ray-induced mutations in *Vicia sativa L.*, 17: 10395
**ZANONI, Paul J.**, Prog. rpt. on high-pressure pump seal, 12/61–2/62, 17: 10778 (NYO-9742)
**ZANONI, Paul J.**, Prog. rpt. on high-pressure pump seal, 3–5/62, 17: 10779 (NYO-9743)
**ZANOWICK, R. L.**, Magnetic characteristics of Gd, Tb and Y hydrides, 17: 11329 (TID-15934)
**ZAPALSKI, Grzegorz**, Fast-slow coincidence circuit with time to pulse-

height converter, 17: 11033
**ZASTAVENKO, L. G.**, Solution of kinetic equations, 17: 11308 (JINR-P-1113)
**ZASTAWNY, Andrzej**, Determining age of samples with C-14, 17: 10834
**ZATZICK, M. R.**, Angular distributions of (n,d) reactions at 14 Mev, 17: 11716
**ZAUBERIS, D. D.**, Neutron and x-ray diffraction studies of non-stoichiometric metal hydrides, 17: 10578 (ANL-FGF-332)
**ZDANIS, R.**, Search for lepton pairs, 17: 11642 (TID-17720(p.98-100))
**ZDANIS, R. A.**, Muon capture on C, 17: 11541
**ZEBOUNI, N. H.**, Electron transport in Zn at liquid-He temperatures, 17: 11378
**ZEGLER, S. T.**, Superconducting phases in Mo–Tc, 17: 11363
**ZEMLYANOV, M. G.**, Delay system for neutron time-of-flight spectroscopy, 17: 11036
**ZEMLYANOV, M. G.**, Studying condensed substance dynamics by neutron scattering, 17: 12032
**ZETKIN, V. I.**, Chlorination of Si-containing monomers and polymers under radiation, 17: 10715
**ZHAVORONKOV, N. M.**, Physiochemical constants of heavy-oxygen $H_2O$, 17: 10657
**ZHILINSKII, A. P.**, Diffusion decay of plasma. III., 17: 11890
**ZHUKOV, A. I.**, Elution of U(VI) ions from sulfocation columns, 17: 10660
**ZHUKOV, V. A.**, Hydrogen–D bubble chamber in magnetic field, 17: 10930
**ZHUKOVSKII, V. M.**, Reduction of $UO_3$ with ammonia, 17: 10725
**ZHUKOVSKII, V. M.**, Uranium oxide reduction with decomposed ammonia, 17: 10726
**ZIELCZYNSKI, M.**, Biological efficiency of radiation, 17: 10448
**ZIEMECKI, Stanislaw**, Effects of $\gamma$ rays on Au chloride solutions, 17: 10696
**ZIGAN, F.**, Calculation of nozzle separation, 17: 11061
**ZIMMERMAN, S. W.**, Deflection methods for 50-Mev proton beam, 17: 11807 (TID-17829)
**ZIMMERMANN, J.**, Conversion of pyrrole to pyridine, 17: 10669 (NP-tr-942)
**ZINN, Walter H.**, Power Reactor Technology, Vol. 6, No. 1, 17: 12009
**ZIPF, K.**, Action of parathyroid hormone on Sr and Ca in bone and blood serum, 17: 10264
**ZITTEL, H. E.**, Controlled-potential coulometric titration of U(IV) and U(VI), 17: 10545
**ZLOTOWSKI, I.**, Ethyl halogenide dissociations in G-M tubes, 17: 11025
**ZLOTOWSKI, Ignacy**, Determining $D_2O$ in $H_2O$, 17: 10566
**ZOELLNER, W.**, Low-energy pion production, 17: 11518
**ZOLLWEG, R. J.**, Ion emission from Cs-coated refractory metals, 17: 11347
**ZOLOTAREV, B. M.**, Mass-spectroscopic study of carbohydrates, 17: 10557
**ZUMWALT, L. R.**, Activity analysis GAIL III-A fuel element, 17: 11944 (GAMD-3378)
**ZUMWALT, L. R.**, Carbon transport and corrosion in GCR, 17: 11981 (GA-2630)
**ZUPRANSKI, Pawel**, Fast neutrons elastically scattered on Ca, 17: 11593 (PAN-354/I-A)
**ZURAKOWSKA-ORSZAGH, Janina**, Effects of radiation on aliphatic polyethers, 17: 10678 (PAN-306/XVII)
**ZVEREV, G. M.**, Millimeter radiospectroscope, 17: 10931
**ZWICKER, U.**, Investigations of Cu–Zr alloys. III., 17: 11225
**ZWICKER, Ulrich**, Phase transformation in Ti–V–Al, 17: 11248
**ZYKOV, V. G.**, Magnetic areas in systems with helical magnetic field, 17: 11879

# SUBJECT INDEX

Main entries in this index are generally specific materials, things, and processes. These are followed by modifiers that describe the properties of, and processes applied to, the main entries. A more complete description of the patterns and style of indexing used is included in the introductions to the subject index cumulations that are issued quarterly.

As an aid to the users of this index, references to report numbers, where appropriate, are included after the abstract number of the citation.

The number preceding the colon is the *NSA* volume number, and the number following is the abstract number in that volume. The designation (R) following the abstract number indicates that the abstract is of a progress report; (P) indicates a patent; and (T) indicates a translation. Abstracts for reports other than progress reports carry no letter designation. Published literature (journal article or book) is identifiable by the absence of a report number.

## A


**ACCELERATORS**
- beam control in, automatic closed-orbit, 17: 11811(T) (NP-tr-932)
- beam control in, computer program for, 17: 11781 (BNL-6189)
- beam transport systems for, use of matrices in synthesis of mirror-symmetric, 17: 11802 (TID-17661)
- beams of, channel design for containing external, 17: 11789 (NYO-10251)
- conference on, 1961 international, 17: 11761 (BNL-767)
- description and use of Danish electron, 17: 11812
- electron production in induction, method for, 17: 11824(P)
- magnet design for switching of, 17: 11807 (TID-17829)
- magnetic field systems for high-energy cyclical, self-adjusting, 17: 11769 (BNL-767(p.91-9))
- magnetic momentum slit design for, 17: 11796 (SLAC-6)
- magnetic systems design for beam of secondary charged particles in, 17: 11790 (PPAD-459F)
- operation of Yale heavy-ion, summary of, 17: 11332(R) (TID-17590)
- operation of Yale electron, summary of, 17: 11332(R) (TID-17590)
- particle collector rings for, design and performance of, 17: 11820
- particle oscillation in cyclic, 17: 11822
- radiation from high-energy, measurement and shielding of, 17: 11809 (UCRL-10163)
- resonant cavity loading in, 17: 11792 (RT/EL(62)15)
- waveguide structure of, shower development and heating in, 17: 11794 (SLAC-3)

**ACENAPHTHYLENE**
- radioinduced polymerization of solid, effects of impurities on rate of, 17: 11283

**ACETATES**
- plutonium potentiometric behavior in, 17: 10654

**ACETIC ACID**
- decomposition of, uranyl sensitized photo-, 17: 10697

**ACETIC ACID, [(CARBOXYMETHYLIMINO) BIS(ETHYLENENITRILO)] TETRA-**
- effectiveness as chelating agent for removal of internally deposited radionuclides, 17: 10333
- effectiveness as chelating agent in plutonium removal, 17: 10334
- effectiveness as chelating agent for removal of internally deposited plutonium-239, 17: 10336
- effectiveness in chelation of deposited thorium-234 and plutonium-239 and removal from rats, effects of physical state of radioisotopes, 17: 10523 (ANL-6637(p.5-8))
- effectiveness in removal of plutonium from blood in rats, 17: 10327
- effectiveness in removal of internally deposited americium, 17: 10335

**ACETIC ACID, (ETHYLENEDIAMINE) TETRA-**
- effectiveness as chelating agent for removal of internally deposited radionuclides, 17: 10333

**ACETIC ACID, (ETHYLENEDIAMINE) TETRA- COMPLEXES**
- with niobium, polarography of, 17: 10544

**ACETIC ACID, (TRIETHYLENETETRAAMINE)HEXA-**
- effectiveness as chelating agent for removal of internally deposited radionuclides, 17: 10333
- effectiveness as chelating agent in plutonium removal, 17: 10334

**ACETONE, THENOYLTRIFLUORO-**
- solvent properties for thorium, effects of aqueous complexation by chelating agent on, 17: 10727 (BNL-6099)
- solvent properties for metals, synergistic effects of tributyl phosphate and trioctylphosphine oxide, 17: 10729 (BNL-6188)

**ACETYLENE**
- radiolysis of, formation of benzene in, 17: 10698
- radiolysis of, in nitrogen, 17: 10509(R) (ORNL-3320(p.30-46))

**ACIDS**
- separation from aqueous solutions by solvent extraction using TBP, 17: 10750 (UCRL-10063)
- separation from gaseous solutions by solvent extraction using TBP, effects of ion hydration on, 17: 10751 (UCRL-10505)
- solvent partition of, between organic extractants and water, theory of, 17: 10767

**ACRYLAMIDE**
- polymers of, adsorption on kaolinite, 17: 11091(R) (MITS-49)

**ACTINIDES**
- atomic structure, 17: 10664
- distribution in tissues in mammals, tracer study, 17: 10324
- removal of internally deposited, effectiveness of DTPA, 17: 10335
- separation by ion exchange, 17: 10771
- separation from lanthanides by liquid-gel extraction using amines, 17: 10740(R) (ORNL-TM-181)

**ACTINIUM ISOTOPES**
- production in alpha reactions in bismuth, 17: 11663
- production in proton reactions in thorium, 17: 11663

**ACTINIUM ISOTOPES Ac-224**
- formation cross section for neon-22 reaction with thorium-232, 17: 11473 (JINR-P-1071)

**ACTINIUM ISOTOPES Ac-225**
- formation cross section for neon-22 reaction with thorium-232, 17: 11473 (JINR-P-1071)

**ACTINIUM ISOTOPES Ac-226**
- formation cross section for neon-22 reaction with thorium-232, 17: 11473 (JINR-P-1071)

**ACTINIUM ISOTOPES Ac-227**
- half life, 17: 10239(R) (MLM-1140)

**ACTIVATION ANALYSIS**
use in evaluation of reduced-pressure backflow preventers, 17: 10515 (ORNL-3380)
use of short-lived radioisotopes in, review on, 17: 10253
**ADENOSINEPHOSPHORIC ACIDS**
effects on alanine assimilation by lipoprotein, tracer studies, 17: 10314
**ADHESIVES**
physical properties of, effects of initial cure temperature on oxiron, 17: 10239(R) (MLM-1140)
**ADRENALINE**
effects of, on radiation injury in central nervous system in mice, 17: 10263
**AEROSOL GENERATORS**
development of, di-octyl phthalate, for inspection of high-efficiency filters, 17: 10922
**AGE ESTIMATION**
facilities for carbon-14, 17: 10834
methods review, 17: 10841
of minerals by radioisotopes, effects of escape of radioactive gases on, 17: 10829
research on carbon and potassium methods, 17: 10243 (NP-12381)
use of radioisotopes in, 17: 10832
**AGRICULTURE**
radiation effects on genetics in, studies on, in United Arab Republic, 17: 10416
use of short-lived radioisotopes in, review on, 17: 10253
**AIR**
air-$H_2O$, heat transfer in flows through parallel-rod arrays, 17: 10812
analysis for plutonium-239, coincidence monitor for, 17: 10532 (HW-SA-2554)
cleaning of, equipment and methods for, 17: 10846 (HW-61840)
corrosive effects on cast uranium carbide, 17: 11106(R) (UNC-5040)
electric discharge in, 17: 11426
monitoring for plutonium, development of semiconductor detectors for, 17: 11012 (UCRL-6692)
thermoelectric effects on nickel and platinum, 17: 11435
**ALANINE**
assimilation by lipoproteins, tracer studies of effects of adenosinephosphoric acids on, 17: 10314
**ALBUMINS**
protective effects against radiation damage in bilirubin and biliverdine, 17: 10376
**ALCOHOLS**
formation in radiolysis of diisopropyl ether, dose rate and temperature effects on, 17: 10705
**ALFALFA**
radioinduced cauliflower-head and single leaf mutation in *Medicago sativa L.*, cytogenetics of, 17: 10398
radioinduced cauliflower-head and single leaf mutations in *Medicago sativa L.*, morphology of, 17: 10399
**ALKALI METAL CHLORIDES**
diffusion of radon-222 and xenon-133 from labeled, during thermal treatment, 17: 10638
**ALKALI METAL HALIDE CRYSTALS**
neutron diffraction measurements of, 17: 10514(R) (ORNL-3320 (p.104-25))
radiolysis, 17: 10509(R) (ORNL-3320(p.30-46))
**ALKALI METAL NITRATES**
use of molten, as media for analytical separation, 17: 10575
**ALKALINE EARTH HALIDES**
heat of fusion, 17: 10513(R) (ORNL-3320(p.98-103))
**ALKALINE EARTH METALS**
solvent extraction by D2EHPA and NaD2EHP, 17: 10739(R) (ORNL-TM-27)
solvent extraction by di(2-ethyl hexyl)phosphoric acid, 17: 10740(R) (ORNL-TM-181)
**ALKANES**
radioinduced polymerization of, mechanism of, 17: 11279
**ALLOYS**
analysis for chromium, cobalt, iron, and nickel, 17: 10539 (TID-16296)
analysis for cobalt, spectrophotometric, 17: 10540 (TID-17745)
bibliography, 17: 11100 (NP-12493)
fatigue test values of light-metal, statistical significance of scatter of, 17: 11245
formation of binary intermediate phases in transition metal, 17: 11235
phase studies of binary and ternary transition metal, 17: 11180 (ANL-FGF-337)
structure of, use of autoradiography in determining, 17: 11208
**ALPHA PARTICLES**
acceleration in Brookhaven AGS, experiments with, 17: 11784 (BNL-6673)
chemical effects on polyethylene, 17: 10674 (BRL-1177)
detection and measurement of, development of scintillating glasses for, 17: 11003 (HW-72512)
detection and measurement of, performance of gas scintillation counter for, 17: 11005 (IKF-5)
detection and measurement from plutonium-239 contamination in air, design of semiconductor instrument for, 17: 11012 (UCRL-6692)
determination in urine, radiometric, 17: 10525 (ANL-6637(p.23-8))
dosage determinations in tissue, 17: 10301(R) (COO-226(p.78-85))
emission in spallation, 17: 11663
excited state of, evidence for 20-Mev, 17: 11526
reactions with scandium-45, cross sections and excitation functions for, 17: 11624 (NYO-10386)
scattering by nuclei, low-lying $3^-$ states from inelastic, 17: 11682
spectrum from proton reactions on carbon-12, 17: 11683
**ALPHA SPECTRA**
spectra from $(\gamma,\alpha)$ reactions on vanadium-51, 17: 11678
**ALTIMETERS**
development for stratosphere, 17: 10902(R) (NYO-9676)
**ALUMINUM**
alloying effects on hardness of beta-quenched uranium, 17: 11097(R) (NMI-7257)
alloying effects on oxidation of zirconium beryllide, 17: 11082(R) (BBC-113)
analysis for impurities, activation, 17: 10546
analysis for impurities, x-ray spectroscopic, 17: 10571
bonding of, stability of adhesives for, 17: 11175
corrosion studies of, technical progress review, 17: 11129
deformation of, piezoelectric pulse measurements during, 17: 11250
determination in concentration products using polonium-210, activation, 17: 10570
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
dielectric constant of, 17: 11861
electric resistivity of, effects of lattice vacancies on, 17: 11231
etching by cathodic arc, 17: 11089 (HW-SA-2559)
nuclear quadrupole resonance, 17: 10592 (IS-520)
oxidation of, mechanisms in anodic, 17: 11138
penetration range of krypton-85 in, 17: 11612 (AFOSR-2975)
powder metallurgy and impact extrusions of, for slugs, 17: 11177
properties for slugs, improvements in, 17: 11177
properties under shock loading, 17: 11937(R) (ARF-4132-16)
proton reactions with, cross sections for bremsstrahlung production in, 17: 11644 (UCRL-7001)
radiation effects, 17: 11129
radiation effects of cosmic mesons, nucleons, and protons on, as space vehicle shielding, 17: 11902 (ORNL-3317)
separation from metal ionic mixtures, electrochromatographic, 17: 10753
solvent properties of liquid, for transition metals, rate of dissolution in, 17: 10577 (ANL-FGF-292)
**ALUMINUM ALLOYS**
corrosion properties and fabrication of, for cladding, 17: 11120
fracture surfaces of, analysis by electron microscopy, 17: 11185 (D1-82-0169)
Al–Cu, effects of cold working on phase segregation in, 17: 11246
Al–Cu, structure of martensitic beta prime phase, 17: 11195 (UCRL-9536)
Al–Cu–Mg, thermal capacity and conductivity at −180 to +200°C, 17: 11200 (USNRDL-TR-599)
Al–Fe, ductility, 17: 11129
Al–Fe, magnetic properties, 17: 10240(R) (NP-12208)
Al–Fe–U, mechanical properties and structure of, 17: 11096(R) (NMI-7256)

Al–Fe–U, mechanical properties and radiation effects, 17: 11095(R) (NMI-7254)
Al–Mg, deformation of, piezoelectric pulse measurements during, 17: 11250
Al–Mg, fatigue test values of, 17: 11245
Al–Mg–Zn, temperature dependence in stress corrosion, 17: 11139
Al–Mn–Ni, composition of X phase in, 17: 11249
Al–Ti–V, mechanical properties, 17: 11099(R) (NP-12475)
Al–Ti–V, phase transformations kinetics in, 17: 11248
Al–U, fabrication of tubular irradiation test specimens of, 17: 11096(R) (NMI-7256)
Al–Zn, effect of cold working on phase segregation in, 17: 11246
Al–Zn, high-ductile state in, 17: 11247

**ALUMINUM CHLORIDES**
reactions with actinide metal chlorides, complex formation in, 17: 10586 (HW-SA-2597)
$AlCl_3$–LiCl–KCl, immiscibility gap in molten phase, 17: 10587 (HW-SA-2621)

**ALUMINUM CRYSTALS**
electron scattering by, energy distributions in, 17: 11757
stress-strain curve for, temperature dependence of, 17: 11233

**ALUMINUM FOILS**
thickness uniformity of commercial, 17: 11104 (TID-16252)

**ALUMINUM HYDROXIDES**
$Al(OH)_3$–$Mg(OH)_2$, crystallization in dialyzed medium, composition and structure of, 17: 10619

**ALUMINUM ISOTOPES Al-25**
energy level transitions in, 17: 11660

**ALUMINUM ISOTOPES Al-26**
determination in stone meteorites, radiometric, 17: 10839

**ALUMINUM ISOTOPES Al-27**
deuteron elastic and inelastic scattering at 12.8 Mev, angular distributions and cross sections for, 17: 11625 (PAN-204)
deuteron reactions (d,$\alpha$) on, statistical model for, 17: 11675
deuteron reactions (d,$He^3$) at 21.6 Mev, angular distributions, 17: 11299(R) (ANL-6612)
energy level of, spin of 2.21-Mev, 17: 11680
energy level spin in, 2.21 Mev, 17: 11686
energy level transitions in, 17: 11660
production in meson ($\pi^-$) reactions, cross sections and yields for, 17: 11650 (UCRL-10531)

**ALUMINUM NITRATES**
$Al(NO_3)_3$–$HNO_3$–$UO_2(NO_3)_2$–$H_2O$, phase diagrams, 17: 10616

**ALUMINUM OXIDE POWDERS**
fabrication by ultrasonic compaction, 17: 11162 (CEND-153(Vol.II) (p.163-94))

**ALUMINUM OXIDES**
use of activated, for chromatographic separation of deuterium, deuterium hydrides, and hydrogen, 17: 11057

**ALUMINUM SYSTEMS**
Al–Si, corrosion properties and fabrication for cladding, 17: 11120
Al–Si–U, mechanical properties and structure, 17: 11096(R) (NMI-7256)

**AMERICIUM**
deposition in bone, reaction mechanisms, 17: 10332
metabolism in rats, tracer study, 17: 10325
removal of internally deposited, effectiveness of DTPA, 17: 10335
solvent extraction using thenoyltrifluoroacetone, synergistic effects of tributyl phosphate and trioctylphosphine oxide, 17: 10729 (BNL-6188)
transfer from plasma to milk in sheep, tracer study, 17: 10326

**AMIDE POLYMERS**
adsorption on kaolinite, 17: 11091(R) (MITS-49)
radiation effects on dielectric losses in, 17: 11278
reactor radiation energy deposition in, 17: 11280

**AMINES**
development for extraction of actinides, iron, lanthanides, and plutonium, 17: 10740(R) (ORNL-TM-181)
radiolysis with methyl methacrylate, formation of cation amine radicals in, 17: 10687
reactions of norbornyl, deamination, 17: 10510(R) (ORNL-3320(p.47-55))
solvent reactions with uranium at aqueous interfaces, mechanism of, 17: 10739(R) (ORNL-TM-27)

**AMINO ACIDS**
sorption by intestine and stomach in dogs, effects of centimeter band radio waves on, 17: 10315

**AMINO ALCOHOLS**
reactions of, deamination, 17: 10510(R) (ORNL-3320(p.47-55))

**AMMONIA**
decomposition of, mass spectrometric measurements of, 17: 10514(R) (ORNL-3320(p.104-25))
hydrogen isotope exchange with hydrogen gas, 17: 11058
radiation effects on reactions with methane, 17: 10704
reaction with uranium(VI) oxides at 300 to 425°C, 17: 10725
reduction of uranium trioxide, 17: 10726
thermoelectric effects on nickel and platinum, 17: 11435

**AMMONIUM CHROMATES**
neutron slowing-down in, cross sections for, 17: 11602

**AMMONIUM COMPOUNDS, QUATERNARY**
osmotic coefficients of halide, 17: 10511(R) (ORNL-3320(p.56-82))
solvent properties for inorganic ions, 17: 10749 (TID-17746)

**AMMONIUM FLUOPHOSPHATES**
neutron slowing-down in, cross sections for, 17: 11602

**AMMONIUM HALIDES**
osmotic coefficients of quaternary, 17: 10511(R) (ORNL-3320(p.56-82))

**AMMONIUM NITRATES**
activity coefficients of cadmium nitrate in concentrated aqueous solutions of, effects of chloride on, 17: 10594 (TID-15741)
reactions with alkaline earth and rare earth elements, thorium, and uranium, precipitation, 17: 10621

**AMMONIUM OXALATES**
reactions with alkaline earth and rare earth elements, thorium, and uranium, precipitation, 17: 10621

**AMMONIUM SULFATES**
neutron slowing-down in, cross sections for, 17: 11602
reactions with alkaline earth and rare earth elements, thorium, and uranium, precipitation, 17: 10621

**AMOEBA**
radiation effects on restoration of RNA in, ultraviolet, 17: 10410

**AMPLIFIERS**
design and performance of, for nuclear instrumentation, 17: 11019
design of d-c, 17: 10899 (NP-12229)
design of fluid-operated, 17: 10889 (AD-252467)
design of low-frequency transistorized, 17: 10892 (BNL-6437)
design of nonoverloading pulse, for scintillation spectroscopy, 17: 11032
design of portable d-c, for ionization current measurements, 17: 10968
design of sensitive, electrometer, for industrial thickness measurements, 17: 11016
use of magnetic, in reactor instrumentation, 17: 10990

**ANALGESICS**
radiation effects on response of rats to, effects of methysurgide, 5-hydroxytryptamine, and cysteamine, 17: 10418

**ANALYSIS**
molten-salt methods of, development of, 17: 10575

**ANEMIA**
pathology of, associated with leukemia, tracer study, 17: 10341

**ANIMAL CELLS**
protection against radiation injury in tissue cultures, effects of biological amines, disulfide compounds, and thiols, 17: 10491
protective effects of blood serum on irradiated, in tissue culture, 17: 10429
radiation effects on intestinal, 17: 10355 (BNL-6113)
radiation effects on guinea pig, cultivated *in vitro*, 17: 10383
radiation effects on reproductive capacity of leukemic, ionization density, 17: 10396
radiation injury in tissue culture, effects of anoxia and various chemicals, 17: 10493
radioautography of tritium-labeled HeLa cells, method for electron microscopic, 17: 10284

**ANIMALS**
radioactivity of organs in, after administration of yttrium fluorides, phosphates, and silicates, 17: 10443
radiotherapy of, using microspheres containing scandium-46 and yttrium-90, 17: 10288

**ANION EXCHANGE MATERIALS**
performance of, with metal complexes, effects of crosslinking on,

17: 10732 (IA-779)
radiation effects on Dowex 1 X-10 hydroxyl resin, 17: 10246(R) (ORNL-TM-403)
sorptive properties of crosslinked Dowex-1 for zinc from aqueous chloride solutions, 17: 10588 (IA-764)
**ANIONS**
association of chromate, cyanide, and nitrate, 17: 10518(R) (TID-17823)
**ANOXIA**
effects on radioinduced chromosome aberrations in grasshoppers, 17: 10492
protective effects against radiation injuries in *Escherichia coli*, 17: 10426
protective effects against radiation injuries in cells in tissue culture, 17: 10493
**ANP REACTOR (SCW)**
shielding design, 17: 11988 (PWAC-100)
**ANTHRACENE**
radioinduced fluorescence of, long-term decay in, 17: 10671 (AERE-M-1153)
**ANTIBODIES**
formation, tracer study, 17: 10255(R) (TID-17648)
role of, in skin graft rejection in irradiated rabbits, 17: 10425
**ANTIGENS**
antibody response, tracer study in mice, 17: 10255(R) (TID-17648)
**ANTIHYPERONS**
annihilation on baryons, distributions from, 17: 11547
**ANTIMONY**
nuclear quadrupole interactions in, 17: 11385
nuclear quadrupole resonance, 17: 10592 (IS-520)
separation from metal ionic mixtures, electrochromatographic, 17: 10753
**ANTIMONY ISOTOPES**
determination, radiometric, 17: 10850(R) (HW-73337(p.77-157))
**ANTIMONY ISOTOPES Sb-121**
nuclear quadrupole resonance in antimony metal, 17: 11385
**ANTIMONY ISOTOPES Sb-122**
beta decay correlations in, 17: 11698
**ANTIMONY ISOTOPES Sb-123**
nuclear quadrupole resonance in antimony metal, 17: 11385
**ANTIMONY ISOTOPES Sb-125**
distribution of inhaled particulate, in body, 17: 10849(R) (HW-73337 (p.29-76))
**ANTIMONY ISOTOPES Sb-134**
half-life, 17: 10849(R) (HW-73337(p.29-76))
**ANTINEUTRINOS**
interactions with nucleons, cross sections for, 17: 11563
**ANTINUCLEONS**
annihilation on baryons, distributions from, 17: 11547
interactions at high energy, experimental and theoretical data on elastic, 17: 11507
**ANTIPROTON BEAMS**
production of 4-Bev, at Argonne, 17: 11803 (TID-17691)
**APATITES**
synthesis of calcium-strontium, 17: 10576 (AE-96)
**ARGON**
determination in reactors by radioactivity measurements, 17: 11948 (HW-SA-2584)
diffusion from minerals, determination of activation energy spectra in, 17: 10830
diffusion in minerals, 17: 10831
electron-ion drift velocities in, 17: 11430
microwave discharge afterglow in, electron density in, 17: 11384
reactions with hot tungsten surface at 1710 to 2500°K, energy exchange in, 17: 10609 (UCRL-10504)
**ARGON ISOTOPES**
measurement of, for use in age measurements, 17: 10243 (NP-12381)
separation by nozzle effusion, dynamics of, 17: 11061
**ARGON ISOTOPES Ar-35**
half life, 17: 11715
**ARGON ISOTOPES Ar-37**
production in meteorites by cosmic radiation, 17: 11448 (BNL-6545)
**ARGON ISOTOPES Ar-39**
production in meteorites by cosmic radiation, 17: 11448 (BNL-6545)
**ARGON ISOTOPES Ar-40**
electronic charge distribution at high energy, 17: 11388
**ARGON ISOTOPES Ar-41**
energy level structure of, shell model analysis of, 17: 11626 (PUC-1962-89)
**ARGON SYSTEMS**
Ar–H, electric discharge in, 17: 10240(R) (NP-12208)
**ARGONNE FAST SOURCE REACTOR**
development, 17: 11935(R) (ANL-6658)
**ARGONNE LOW POWER RESEARCH REACTOR**
control rod calibration for, development of digital method of, 17: 11964 (TID-17815)
**ARGONNE RESEARCH REACTOR**
development, 17: 11935(R) (ANL-6658)
**ARGONNE SYNCHROTRON**
beam ejection by a pulsed magnet, 17: 11801 (TID-17652)
beam extraction system for, characteristics of BM-102 magnets in, 17: 11804 (TID-17693)
beam size control, 17: 11800 (TID-17642)
beams of, proposal for 4 Bev/c antiproton, 17: 11803 (TID-17691)
proton acceleration from 50 Mev to 12.5 Bev in, 17: 11494 (TID-17627)
**ARMY REACTORS (ML-1)**
operation, spectral analysis, 17: 11978 (AGN-TM-399)
**ARMY REACTORS (PM-3)**
hazards summary corrections for as-built conditions, 17: 11985 (MND-M3A-2496(Vol.I)(Add.))
**ARMY REACTORS (SL-1)**
accident recovery operations, phase 3, 17: 11983 (IDO-19311)
**ARSENIC**
determination in biological materials, activation, 17: 10542
determination in pure phosphorus, activation, 17: 10562
determination in zinc using Gutzeit method, 17: 10563
nuclear quadrupole resonance, 17: 10592 (IS-520)
separation from metal ionic mixtures, electrochromatographic, 17: 10753
**ARSENIC ISOTOPES As-74**
differential uptake by brain tumors, appraisal for localization of tumors by external counting, 17: 10278
**ASTATINE ISOTOPES**
beta decay correlations in, 17: 11698
**ASTATINE ISOTOPES At-217**
alpha half life of, 17: 11632 (TID-16202)
**ASTROPHYSICS**
cosmic-radiation generation in nebulae in, 17: 11456
neutrino pair emission by stellar plasma, 17: 11446
**ATLANTIC OCEAN**
strontium-90 content in surface waters of, 1959–60, 17: 10835
**ATMOSPHERE**
particle diffusion and transfer, meteorological factors, 17: 10848(R) (HW-73337(p.1-28))
pollution by radon daughter products, method for determining, 17: 10560
radiation monitoring in France during September 1962, 17: 10864 (SCPRI(RM) 62-9)
radiation monitoring in France during October 1962, 17: 10865 (SCPRI (RM) 62-10)
status of meteorological knowledge as factor in pollution control, 17: 10843 (BNL-6538)
wave propagation in, from thermonuclear explosions, 17: 10837
**ATOMIC BEAMS**
channeling in crystals at 10 kev, 17: 11348
interaction with electron beams, 17: 11319 (NP-12358)
**ATOMIC ENERGY**
activities of CEA, 1961, 17: 10241 (NP-12324)
**ATOMIC EXPLOSIONS**
effects of, design of circular slide rule for evaluating, 17: 10845 (CEX-62.2)
effects of, on thyroid function in children exposed *in utero* in Nagasaki, 17: 10371
seismic data for on-site inspection, Vela Project, 17: 10238(R) (AD-278378)
seismic data for STILLWATER, 17: 10244 (NP-12444)
seismic signals from GNOME, compilation of recordings of, 17: 10824 (NP-12462)

seismic waves from ARMADILLO, analysis of measurements of, 17: 10823 (NP-12445)
thermal radiation transmission from, in real atmospheres, 17: 11298 (AFCRL-62-456)
**ATOMIC MASSES**
determination of, by chemical procedures and mass spectrometry, sources of error in, 17: 10614
**ATOMIC PHYSICS**
momentum region in Thomas-Fermi theory, modification of, 17: 11309 (LA-2750)
**ATOMS**
angular momentum transport in quantum statistical mechanics of, 17: 11917
energy of sputtered, 17: 11374
exchange intergrals between functions of K or L and O shells for equal nuclear charge, 17: 11344
interactions with ions in gases, scattering and charge exchange cross sections for, 17: 11340(T) (AEC-tr-5615)
spin couplings of, Heitler-London method of calculation of, 17: 11420
transition probabilities of, statistics of radiative, 17: 11373
**AUDITORY ORGANS**
radioinduced dermititis on rabbits' ears, reactions of boron-10 and thermal neutrons, 17: 10475
**AZOETHANE, 1,1'-DIPHENYL-**
thermal decomposition of, deuterium isotope effects in, 17: 10665 (BNL-6174)

## B

**BACTERIA**
growth in reactor cooling systems, control of, 17: 11136
radiation effects on formic acid, glucose, and pyruvic acid metabolism by, 17: 10468
radiation effects, biochemical and genetic, 17: 10366(R) (TID-17697)
radiation effects on *Clostridium botulinum* spores in meat, effects of low temperatures on, 17: 10883
radiosensitivity of *Pseudomonas aeruginosa*, effects of oxygen concentration, 17: 10419
**BARITE CONCRETES**
shielding properties of, tests on, 17: 11218
**BARITES**
shielding properties, 17: 11205
**BARIUM**
nuclear quadrupole resonance, 17: 10592 (IS-520)
reactions with ammonium nitrates and oxalates and potassium and sodium sulfates, precipitation, 17: 10621
separation from metal ionic mixtures, electrochromatographic, 17: 10753
**BARIUM BORIDES**
electric properties, 17: 11306 (IS-473)
**BARIUM CHLORIDES**
BaCl–NaCl, testing for use in viscous protection of high-temperature dies, 17: 11081(R) (ASD-TR-7-886(Vol.VII))
**BARIUM ISOTOPES Ba-131**
decay and half life of 14.5-min isomer of, 17: 11712
decay and half life of metastable, 17: 11713
**BARIUM ISOTOPES Ba-140**
energy of, from 23-Mev deuteron fission of uranium-238, 17: 11646 (UCRL-10193)
**BARIUM NITRATES**
salting-out properties in uranyl nitrate extraction from aqueous solutions, 17: 10770
**BARIUM SULFATES**
reduction by hydrogen, 17: 10246(R) (ORNL-TM-403)
**BARLEY**
radiation effects on, relation of embryo structure, node position, planting depth, and tillering to, 17: 10453
radiation effects on nucleic acid and protein metabolism in seedlings of, 17: 10456
radiation effects on embryonic-endo sperm ratio in, gamma, thermal neutron, and x, 17: 10386
**BEARINGS**
development of gas-lubricated, for turbo-machinery, 17: 10781(R) (TID-17311)
development of gas-lubricated, for high-speed rotating machinery, 17: 10782 (TID-17756)
**BEHAVIOR**
radiation effects on fixation and maze performance in rats, cranial, 17: 10430
**BELGIAN REACTOR-2**
operation at 50 Mw, estimation from neutron beam characteristics, 17: 12022 (BLG-147)
**BENZENE**
adsorption by quartz under water, effects of hysteresis angles on, 17: 11091(R) (MITS-49)
adsorption by rutile under dodecyl ammonium chloride-water solutions, effects of hysteresis angles on, 17: 11091(R) (MITS-49)
chemical effects on solvent extraction of uranyl sulfate using tri-n-octylamine, 17: 10756
luminescence and scintillation properties of 2,5-diaryl oxazole derivatives of, in polystyrene, 17: 11227(T)
production in radiolysis of acetylene, 17: 10698
**BENZENE, BROMO-**
neutron reactions (n,γ) in, electric field separation of products from, 17: 10702
**BENZENE, CHLORO-**
radiolysis of, gamma, 17: 10716
**BENZENE, NITRO-**
solvent properties for cesium in aqueous solutions, 17: 10757
solvent properties for cesium in aqueous solutions, 17: 10759
**BENZENEARSONIC ACID, o-(2-HYDROXY-3,6-DISULFONAPHTHYLAZO)-, SODIUM SALTS**
analytical use in colorimetric determination of thorium, 17: 10561
**BENZENEBORONIC ACIDS**
3-amino-4-carboxy-, effectiveness for neutron capture therapy of brain tumors in man, 17: 10282
**BENZOIC ACID, *p*-(DIPROPYLSULFAMYL)-**
preparation of labeled, by activation, 17: 10683
**BENZOPHENONES**
photoreduction in 2-propanol, effects of retarders on, 17: 10680(R) (TID-17584)
**BERYLLIUM**
alloying effects on copper-zirconium alloys, 17: 11225
bremsstrahlung reactions (γ,p) at 335 Mev, 17: 11704
content in granite diorites in Mount Capanne and the Island of Giglio, 17: 10827
determination in concentration products using polonium-210, activation, 17: 10570
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
diffusion in tungsten at 1000 to 1200°C, 17: 11214
electric resistivity of, effects of lattice vacancies on, 17: 11231
fabrication, 17: 11127
nuclear quadrupole resonance, 17: 10592 (IS-520)
physical properties, 17: 11127
production of spherical particles, feasibility, 17: 11101 (NUMEC-P-49)
protons reactions with, cross sections for bremsstrahlung production in, 17: 11644 (UCRL-7001)
separation from fission products by coordination complexes, 17: 10498 (AAEC/TM-161)
toxic effects on man, clinical picture of, 17: 10313
**BERYLLIUM ALLOYS**
properties of, technical progress review, 17: 11127
Be–Fe, magnetic properties of, 17: 10240(R) (NP-12208)
Be–W, phase studies and structure, 17: 11214
Be–Zr, properties, 17: 11082(R) (BBC-113)
**BERYLLIUM COMPLEXES**
chemistry of coordination, literature survey, 17: 10498 (AAEC/TM-161)
**BERYLLIUM CRYSTALS**
preparation and properties of zone-refined, 17: 11094(R) (NMI-2113)
preparation of ultra-high purity, by zone refining, 17: 11093(R) (NMI-2112)
**BERYLLIUM FLUORIDES**
enthalpy and entropy of vaporization of, at 550 to 950°C, 17: 10627
**BERYLLIUM IONS**

energy levels of, 20-parameter eigenfunctions and energies of $^2S$ states of, 17: 11751
**BERYLLIUM ISOTOPES Be-7**
production and separation of, method for, 17: 10676 (NP-12231)
production in carbon-12 (p,3p3n) reactions, cross sections for, 17: 11663
**BERYLLIUM ISOTOPES Be-9**
deuteron pickup by, angular momentum in, 17: 11662
neutron reactions (n,2n), direct interactions in, 17: 11669
proton reactions (p,2p), cross sections for, 17: 11703
**BERYLLIUM OXIDES**
growth of single crystals of, methods for, 17: 11122
mechanical properties of porous, 17: 11226
neutron total cross sections at 100 to 1000°K, cold, 17: 11671
properties and structures of mixed, 17: 11194 (TRG-Report-408)
properties of, technical progress review, 17: 11127
radiation effects, review, 17: 12014
transition probabilities of, relative, 17: 10624
**BERYLLIUM OXIDES (IMPREGNATED)**
radiation effects on, at high burnup, 17: 11270 (WAPD-T-1455)
**BETA DECAY**
theory of, feasibility of testing corrections predicted by Feynman–Gell–Mann, 17: 11641(R) (TID-17720(p.90-7))
theory of, matrix element ratio in, 17: 11664
vector transitions in, expansion of Siegert theorem for, 17: 11758
**BETA PARTICLES**
detection and measurement in solutions of formamide, radiometric, 17: 10526 (ANL-6637(p.29-31))
detection and measurement, performance of proportional detector, 17: 10850(R) (HW-73337(p.77-157))
determination in urine, radiometric, 17: 10525 (ANL-6637(p.23-8))
effects on immunological reactions in postoperative corneal grafts, 17: 10439
monitoring stack gases for, design of detector for, 17: 11017
sorption in polymers, effects of temperature on, 17: 11282
**BETA SOURCES**
design for intragastric irradiation, 17: 10367 (TID-17727)
use in measuring pulverized coal in pneumatic conveyers, 17: 10881(T) (AEC-tr-5581)
**BETA SPECTRA**
analysis of continuous, computer program for, 17: 11443
**BETATRONS**
beam intensity, effects of injector focusing on, 17: 11816
beam orbits in, electron capture in, 17: 11810 (USASRDL-TR-2257)
bremsstrahlung production at internal anticathode of, mechanism of, 17: 11821
design of cylindrical iron-free, with axial magnetic focusing, 17: 11823
electron displacement from equilibrium orbit in, method for, 17: 11825(P)
**BEVATRON**
radiation from, measurement and shielding of, 17: 11809 (UCRL-10163)
**BIBLIOGRAPHIES**
on bore-hole radiometry, 17: 10842
on chemical methods of radiation dosimetry, 17: 10998 (AERE-R-4189)
on chronic strontium ingestion, 17: 10306 (HW-SA-2577)
on coordination chemistry of beryllium, 17: 10498 (AAEC/TM-161)
on corrosion inhibitors for high purity water, 17: 11137
on cosmic rays, for 1956 to 1960, 17: 11457
on cross sections for neutron inelastic scattering and (n,2n) processes, 17: 11587 (AE-88)
on decontamination of radioactive water, 17: 12043 (NP-12482)
on defense metals and materials, 17: 11100 (NP-12493)
on direct energy conversion, 17: 11322 (NP-12429)
on fabrication of fuel elements by powder compaction, 17: 12013
on failure of reactor fuels, 17: 11956 (TID-3573)
on heat transfer in nuclear engineering, 17: 12012
on interaction between geomagnetic field and solar corpuscular radiation, 17: 11449 (ML-975)
on neutron cross sections, 17: 11613 (BNL-768)
on new resonances in particle interactions, 17: 11464 (AFOSR-2978)
on nonaqueous conductance, 17: 10504 (NYO-9696)
on oceanography of Santa Barbara channel area, 17: 10826 (TID-17722)
on organic-cooled reactors, 17: 12018
on production and use of strong pulsed magnetic fields, 17: 11442
on radiation effects on reactor fuels, 17: 11269 (VDIT-16(2.4))
on radiation geology, 17: 10841
on radioisotope milking systems, 17: 11050 (BNL-6697)
on reactor physics, 17: 12011
on selected borides, 17: 10579 (ASD-TDR-62-873)
on two-condition flip-flop stages with complementary transistors, 17: 10921(T) (SCL-T-460)
on vaporization properties of uranium sulfides, 17: 10598 (TID-15796)
on weldability of metals, 17: 11166 (HW-SA-2527)
**BIG ROCK POINT POWER REACTOR**
stability of, evaluation in pre-startup simulations, 17: 11945(R) (GEAP-4096)
**BILIRUBIN**
radiation effects on, protective effects of proteins against, 17: 10376
**BILIVERDINE**
radiation effects on, protective effects of proteins against, 17: 10376
**BIOLOGICAL MATERIALS**
analysis for arsenic, activation, 17: 10542
analysis for plutonium, radiochemical, 17: 10298(R) (COO-226(p.58-65))
analysis for radium-226, radiochemical, 17: 10529 (ANL-6637 (p.59-84))
**BIOMETRY**
mathematical analysis of data on urinary excretion of uranium to determine lung burden, 17: 10311 (Y-KB-1)
uranium exposure, mathematical treatment of urinalysis data, 17: 10305 (HASL-120)
**BISMUTH**
alpha reactions in, actinium isotopes from, 17: 11663
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
diffusion of liquid, into boundaries of oriented nickel bicrystals, 17: 11241
hydrolysis of trivalent, 17: 10511(R) (ORNL-3320(p.56-82))
neutron transport in, 17: 11598 (TID-16304)
nuclear quadrupole resonance, 17: 10592 (IS-520)
**BISMUTH ALLOYS**
Bi–Mg, solvent properties for cerium and uranium from chloride eutectic at 500°C, 17: 10581 (BNL-639)
Bi–Pb, a-c losses in superconducting, 17: 11372
**BISMUTH CRYSTALS**
growth of single, 17: 10502 (IS-542)
**BISMUTH ISOTOPES Bi-205**
decay energy, 17: 11612 (AFOSR-2975)
**BISMUTH ISOTOPES Bi-206**
production and separation of, method for, 17: 10676 (NP-12231)
**BISMUTH ISOTOPES Bi-208**
half-life, 17: 10506(R) (ORNL-3320(p.1-15))
**BISMUTH ISOTOPES Bi-210**
beta decay of, matrix elements ratio for, 17: 11664
neutron activation cross sections, 17: 10506(R) (ORNL-3320(p.1-15))
**BISMUTH ISOTOPES Bi-214**
pollution of atmosphere by, method for determining, 17: 10560
**BISMUTH SULFIDES**
thermodynamics of liquid solutions of, at 705 to 800°C, 17: 10629
**BISMUTH TELLURIDES**
thermoelectric properties, 17: 11294(R) (AD-277223)
**BLADDER**
radiation dose rate to, from therapy of carcinoma of uterine cervix, 17: 10259
**BLOOD**
analysis for tritium as vitamin A by liquid scintillation, 17: 10552
radiation effects on, effects of foreign spleen cells in mice on, 17: 10434
strontium content in rat, age and sex dependence of, 17: 10347
zinc distribution and turnover in, in rats, tracer study, 17: 10275
**BLOOD CELLS**
radiation effects on chromosomes in, from diagnostic radiography, 17: 10435
synthesis of DNA in peripheral, effects of colloidal silver, hemorrhage, and x radiation on, 17: 10291
**BLOOD COAGULATION**
radiation effects in man, occupational, 17: 10446

**BLOOD PICTURE**
effects of injected radium-226 on, in dogs, 17: 10297(R) (COO-226(p.50-6))
use in evaluation of radiation injury, 17: 10447
**BLOOD PLASMA**
radiation effects on iron-59 clearance from, in bone marrow in rats, 17: 10413
**BLOOD SERUM**
binding of rare earth and rare earth chelates to proteins and nucleic acids, tracer study, 17: 10307 (TID-17522)
calcium and strontium in, mechanism of parathyroid hormone effects on, 17: 10264
protective effects against radiation injury of cells in tissue culture, 17: 10429
**BLOOD VESSELS**
coronary arteriography by single exposure, method for obtaining, 17: 10267
radiation effects of cyclotron on peripheral, in workers, 17: 10444
radiation injuries, effects of diet, 17: 10485(R) (NP-12251(p.99-113))
radiosterilization of, effects on hetero- and homotransplantation, 17: 10450
use of, in delivering cancerocidal agents to tumor zones, 17: 10288
**BLOWERS**
status for gas-cooled reactors, 17: 12019
**BOILERS**
economics of, for gas-cooled reactors, 17: 12000
**BOILING**
burnout heat flux limits for subcooled water in annulus, 17: 11979(R) (DP-805)
burnout in flow through vertical annuli, 17: 10789 (AE-100)
burnout upstream of outlet in uniformly heated channels, 17: 10794 (HW-73902(Rev.))
critical burnout in, 17: 10807(T,R) (EURAEC-449)
critical heat fluxes for polyphenyl coolants, 17: 10800 (NAA-SR-7954)
void coefficients in air-water flows through parallel-rod arrays, 17: 10812
**BOILING REACTOR EXPERIMENTS**
development of BORAX-V, 17: 11935(R) (ANL-6658)
fuel plates for, fabrication and inspection of, 17: 11078 (ANL-FGF-329)
operation of BORAX-V, 17: 11936(R) (ANL-6672)
**BOILING REACTORS**
heat transfer and stability in, 17: 11980(R) (EURAEC-414)
hot spot calculations for, statistical methods of, 17: 11943(R) (EURAEC-500)
kinetics of, effects of delayed neutrons on shape of distribution curve in, 17: 11949 (IFK-2)
radioactivity distribution after fuel failure, loop studies, 17: 11959 (TID-15779)
reactivity fluctuations in, mean-square minimization of, 17: 12008
stability of, tests of hydrodynamics, 17: 11966(T,R) (EURAEC-465)
**BONDING**
adhesives for metal, stability of, 17: 11175
techniques for, development of, 17: 11130
**BONE MARROW**
immunological tolerance in radiation chimeras, 17: 10270
protective effects of isogenic injections of, on lethally irradiated rats, 17: 10437
protective effects of isologous, on radiation injuries in mice, 17: 10283
radiation and encephalomyelitis virus effects on, in guinea pigs, 17: 10427
radiation effects on chromosomes in, from diagnostic radiography, 17: 10435
radiation effects on, in rats, 17: 10413
radiation injuries in, effects of spleen extract injections in guinea pigs on, 17: 10369
radiation sickness effects on maturation and proliferation of, in animals, 17: 10495
thymidine metabolism in, tracer study, 17: 10292 (BNL-6106)
transfusions, effectiveness in bone marrow repopulation in man, 17: 10292 (BNL-6106)
**BONE TUMORS**
detection of metastatic, by external counting after administration of calcium-47 or strontium-85, 17: 10344
localization of metastases by external scanning after administration of strontium-85, 17: 10279
**BONES**
americium, plutonium, and yttrium deposition reaction mechanisms, 17: 10332
calcium and strontium in, mechanism of parathyroid hormone effects on, 17: 10264
metabolism of calcium and strontium in human, tracer study on comparative kinetics, 17: 10293 (BNL-6108)
plutonium deposition in rachitic rats, tracer study, 17: 10330
plutonium deposition, reaction mechanisms, 17: 10331
plutonium deposition in histopathologic effects of, in dogs, 17: 10346
radium dosimetry in, 17: 10302(R) (COO-226(p.86-94))
strontium content in rat, age and sex dependence of, 17: 10347
strontium metabolism in rat, effects of testosterone on, 17: 10348
transplantation, effects of estradiol valerate and sulfated mucopolysaccharides on ossification, 17: 10304(R) (COO-226(p.128-30))
vascularity of spongy, 17: 10304(R) (COO-226(p.128-30))
zinc distribution and turnover in, in rats, tracer study, 17: 10275
**BORAZOLE**
decomposition of, radiolytic and thermal, 17: 10700
**BORIDES**
bibliography on preparation and properties of, 17: 10579 (ASD-TDR-62-873)
**BORON**
bremsstrahlung reactions ($\gamma$,p) at 335 Mev, 17: 11704
determination in concentration products using polonium-210, activation, 17: 10570
determination in reactor fuels, 17: 11303(R) (HW-75228)
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
neutron absorption by, in reactor poison, 17: 11629 (TID-15884)
neutron capture in PWR-2 fuel assembly, 17: 11995 (WAPD-T-1371(Rev.))
neutron effective cutoff energies, 17: 10506(R) (ORNL-3320(p.1-15))
nuclear quadrupole resonance, 17: 10592 (IS-520)
**BORON CARBIDES**
formation in carbon reaction with boron and cerium oxides, 17: 10662
$B_4C$–graphite, preparation, radiation effects, and stability under reactor conditions, 17: 11085 (GA-3064)
**BORON FLUORIDE COMPLEXES**
properties and reactions of organic, 17: 10508(R) (ORNL-3320(p.22-9))
**BORON FLUORIDES**
addition products of, formation kinetics of, 17: 10508(R) (ORNL-3320 (p.22-9))
stability of, radiation and thermal effects on, 17: 10516 (ORNL-TM-475)
**BORON HYDRIDES**
stability of, radiation and thermal effects on, 17: 10516 (ORNL-TM-475)
**BORON IONS**
energy levels of, 20-parameter eigenfunctions and energies of $2^4S$ states of, 17: 11751
**BORON ISOTOPES B-9**
excited states of, evidence for 1.7-Mev, 17: 11683
**BORON ISOTOPES B-10**
deuteron stripping by, angular momentum in, 17: 11662
magnetic dipole transitions from ground state to T = 1 states, 17: 11299(R) (ANL-6612)
neutron reactions (n,$\alpha$) with, relative biological effectiveness of, for animals and man, 17: 10475
neutron reactions (n,$\alpha$), energy of particles emitted by, 17: 11670
**BORON ISOTOPES B-11**
deuteron reaction (d,p) in, computer programs for study of polarization of protons from, 17: 11639(R) (TID-17720(p.62-78))
deuteron reactions (d,n) in, nuclear polarization in, 17: 11637(R) (TID-17720(p.15-37))
deuteron reactions (d,n) at 1.6 to 2.7 Mev, cross sections for, 17: 11693
energy level at 2.13 Mev, parity of, 17: 11707
helium nucleus reactions (helium-3,p), 17: 11721
**BORON ISOTOPES B-12**
polarization of, from boron-11 (d,p) reactions, 17: 11637(R) (TID-17720 (p.15-37))
**BORON OXIDES**

$B_2O_3$–$CeO_2$, reduction by carbon, 17: 10662
$B_2O_3$–$La_2O_3$, reduction by carbon, 17: 10662
**BOROÖRGANIC COMPOUNDS**
therapeutic effects on brain tumors in man, neutron capture, 17: 10282
**BOSONS**
interactions of, model of weak, 17: 11562
interactions of spinless, with spin-½ fermions, 17: 11570
phonon-phonon interactions in systems of, 17: 11411
reduced density matrices in coordinate space representation, 17: 11423
representations in field theory, spins 0 and 1, 17: 11509
selection rules for spin-½, 17: 11524
superconducting properties of, effects of weak repulsive forces on, 17: 11582
**BRAIN**
radiation effects on rat, gamma and x, 17: 10459
radiation effects on Purkinje cells in, 17: 10460
radiotherapy of cerebral astrocytomata in man, effects of whole-body hypothermia on, 17: 10438
**BRAIN TUMORS**
localization after administration of arsenic-74 or copper-64 by positron scanning, 17: 10357 (BNL-6572)
localization by external scanning after administration of arsenic-74, 17: 10278
localization of, using iodine-131-labeled polyvinylpyrrolidone in cats, 17: 10287
therapy of, use of boron-10 particles and thermal neutrons for, 17: 10475
therapy using boron compounds in man, neutron capture, 17: 10282
**BRASS**
valence of manganese in alpha and beta, from magnetic measurements, 17: 11297 (AE-95)
**BRAZING**
techniques for, development of, 17: 11130
**BREASTS**
yttrium-90 therapy of carcinomas of, histological effects on pituitary gland in, 17: 10451
**BREEDER REACTORS**
construction and principles of fast, 17: 12021
**BREMSSTRAHLUNG**
absorption in cylinders, measurements of energy losses in, 17: 11585
production at betatron internal anticathode, 17: 11821
production by proton reactions with nuclei, cross sections for, 17: 11644 (UCRL-7001)
**BROMATES**
nuclear quadrupole resonance, 17: 10592 (IS-520)
**BROMIDES**
nuclear quadrupole resonance, 17: 10592 (IS-520)
**BROMINE**
meson ($\pi^-$) capture by, single charged particle emission in, 17: 11679
neutron reactions (n,γ), electric field separation of recoil products from, 17: 10702
nuclear quadrupole resonance, 17: 10592 (IS-520)
**BROMINE FLUORIDES**
$BrF_3$–$UF_4$, vapor pressure equilibrium, 17: 10595 (TID-15770)
**BROMINE ISOTOPES Br-82**
annealing in irradiated crystalline hexabromoethane, effects of defects on, 17: 10673 (BNL-6535)
**BROMOFORM**
reactions with pyrroles, 17: 10668(T) (NP-tr-941)
**BROMOÖRGANIC COMPOUNDS**
annealing of recoil bromine-82 in, effects of defects on, 17: 10673 (BNL-6535)
**BROOKHAVEN ALTERNATING-GRADIENT SYNCHROTRON**
beam current in, methods for measurements of injected, 17: 11782 (BNL-6645)
beam separator for, analysis of waveguide deflecting mode of, 17: 11783 (BNL-6670)
heavy-particle acceleration in, possible experiments with, 17: 11784 (BNL-6673)
operation of, summary of Brookhaven-Yale research, 17: 11332(R) (TID-17590)
**BROOKHAVEN REACTOR**
operation of, 12-year summary of, 17: 12031
**BROOKHAVEN SYNCHROTRON**
beam ejector of, improvements on, 17: 11785 (BNL-6678)
**BUBBLE CHAMBERS**
design and performance of 8-liter deuterium–hydrogen, 17: 10930
particle track measuring stage for, 17: 11001 (BNL-6095)
track-centering device for, with digitized output for, 17: 11000 (BNL-6094)
**BUBBLES**
collapse in subcooled liquid, research program, 17: 10803(R) (TID-17719)
motion in turbulent flow, research program, 17: 10803(R) (TID-17719)
**BUILDING MATERIALS**
stress analyses of, for reactor containment, 17: 11937(R) (ARF-4132-16)
**BUTADIENE POLYMERS**
beta sorption and glass transition in, effects of temperature on, 17: 11282
**1-BUTANOL**
1-butanol–hexane, theory of ionic dissociation of lithium iodide in, 17: 10656
**BUTENE POLYMERS**
beta sorption and glass transition in, effects of temperature on, 17: 11282
**BUTYL ETHER**
solvent properties for uranium, 17: 10755
**BUTYL PHOSPHATES**
determination in kerosene-base solvents by x-ray absorption analysis, 17: 10536 (NP-12398)
effects on the extraction performance of AMSCO in nitric acid, 17: 10739(R) (ORNL-TM-27)
reactions with sodium nitrates, thermal effects on, 17: 10510(R) (ORNL-3320(p.47-55))
solvent properties for plutonium, thorium, and uranium, 17: 10738 (ORNL-3374)
solvent properties for acids, 17: 10750 (UCRL-10063)
solvent properties for acids, effects of ion hydration on, 17: 10751 (UCRL-10505)
solvent properties for cerium and thorium, 17: 10760
solvent properties for rare earths, 17: 10764
solvent properties for uranyl nitrates in aqueous solutions, 17: 10770
synergistic effects of tri-, on solvent extraction by thenoyltrifluoroacetone, 17: 10729 (BNL-6188)
vapor pressure of tri-, over aqueous nitric acid solution, 17: 10246(R) (ORNL-TM-403)
kerosene–TBP–$UO_2(NO_3)_2$, analysis for free acidity, design of meter for, 17: 10972
**BUTYLAMINE**
distillation of, with carbon dioxide, isotope effects in, 17: 10521
**2-BUTYNE**
neutron slowing-down in, cross sections for, 17: 11602

## C

**CADMIUM**
determination in aluminum as trace impurity, activation, 17: 10546
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
electric resistivity of, effects of lattice vacancies on, 17: 11231
neutron angular distributions at the surface of rods of, in the center of a reactor, 17: 11303(R) (HW-75228)
neutron effective cutoff energies, 17: 10506(R) (ORNL-3320(p.1-15))
oxidation at high temperatures, mechanism of, 17: 11135(T,R) (EURAEC-483)
**CADMIUM ALLOYS**
Cd–Mg–Zn, creep properties, 17: 11179 (AERE-M-1149)
**CADMIUM CHLORIDES**
$CdCl_2$–KCl, electric conductivity and ion formation in liquid, 17: 10513(R) (ORNL-3320(p.98-103))
**CADMIUM COMPLEXES**
with chloride ion in concentrated aqueous solutions of ammonium nitrate, formation constant, 17: 10594 (TID-15741)
**CADMIUM CRYSTALS**
growth of single, 17: 10502 (IS-542)

**CADMIUM ISOTOPES**
determination in mixed fission products, radiochemical, 17: 10850(R) (HW-73337(p.77-157))
**CADMIUM ISOTOPES Cd-108**
energy levels, 17: 11685
**CADMIUM ISOTOPES Cd-110**
energy levels, 17: 11685
**CADMIUM ISOTOPES Cd-111**
gyromagnetic factor, 17: 11612 (AFOSR-2975)
**CADMIUM ISOTOPES Cd-114**
energy levels, 17: 11685
**CADMIUM ISOTOPES Cd-115**
energy of, from 23-Mev deuteron fission of uranium-238, 17: 11646 (UCRL-10193)
**CADMIUM NITRATES**
activity coefficients in concentrated aqueous solutions of ammonium nitrate at 40°C, effects of chloride on, 17: 10594 (TID-15741)
salting-out properties in uranyl nitrate extraction from aqueous solutions, 17: 10770
**CADMIUM SULFIDE CRYSTALS**
luminescent properties of, effect of photochemical processes on, 17: 10637
radiation effects of electrons on, mechanisms of, 17: 11290
**CADMIUM SULFIDES**
light emission during electron bombardment, 17: 11317 (NP-12322)
properties of, for use as radiation detector, 17: 11006 (NP-12376)
**CALCIUM**
content in blood serum and bones in rats, mechanism of parathyroid hormone effects on, 17: 10264
excretion in urine, tracer study, 17: 10310(R) (TID-17789)
metabolism, effects of levels of lactose and vitamin D, 17: 10310(R) (TID-17789)
metabolism in skeleton of man, tracer study, 17: 10293 (BNL-6108)
neutron scattering at 3 to 4 Mev, elastic, 17: 11593 (PAN-354/I-A)
reactions with ammonium, potassium, and sodium salts, precipitation, 17: 10621
separation from trivalent rare earths by cation exchange, 17: 10734 (IS-508
solvent extraction using thenoyltrifluoroacetone, synergistic effects of tributyl phosphate and trioctylphosphine oxide, 17: 10729 (BNL-6188)
transfer from plasma to milk in sheep, tracer study, 17: 10326
**CALCIUM BORIDES**
electric properties, 17: 11306 (IS-473)
**CALCIUM CARBONATES**
solid-phase reactions of, at high pressures, 17: 10503 (NP-12359)
**CALCIUM FLUORIDE CRYSTALS**
coloration of, by deuteron bombardment, electric currents, and presence of metallic vapor, 17: 10640
properties as gamma scintillators, 17: 11044
**CALCIUM ISOTOPES Ca-40**
alpha reactions (α,p) at 14 Mev, proton angular distributions, 17: 11612 (AFOSR-2975)
excited states of, inelastic alpha excitation of, 17: 11682
gamma reactions (γ,n) and (γ,np) on, cross sections for, 17: 11672
proton inelastic scattering by, dipole-resonance effects on, 17: 11734
proton shell structure of, proton-proton scattering study of, 17: 11677
**CALCIUM ISOTOPES Ca-42**
neutron reactions (n,p), cross sections for, 17: 11651
**CALCIUM ISOTOPES Ca-43**
neutron reactions (n,p), cross sections for, 17: 11651
**CALCIUM ISOTOPES Ca-45**
production and separation of, method for, 17: 10676 (NP-12231)
**CALCIUM ISOTOPES Ca-47**
production and separation of, method for, 17: 10676 (NP-12231)
uses in medicine, review on, 17: 10274
**CALCIUM ISOTOPES Ca-48**
neutron reactions (n,2n) at 14.5 Mev, cross sections for, 17: 11614 (BNL-6044)
**CALCIUM NITRATES**
salting-out properties in uranyl nitrate extraction from aqueous solutions, 17: 10770
**CALCIUM OXIDES**
properties and structures of mixed, 17: 11194 (TRG-Report-408)
**CALCIUM SULFATES**
reduction by hydrogen, 17: 10246(R) (ORNL-TM-403)
**CALCIUM TUNGSTATES**
neodymium excitation in, lifetime of, 17: 10651
**CALDER HALL REACTORS**
instrument maintenance procedures and problems, 17: 10997
instrumentation for, operational view of, 17: 10995
**CALIFORNIA**
oceanography of Santa Barbara channel area, 17: 10826 (TID-17722)
**CALIFORNIUM ISOTOPES Cf-246**
separation by solvent extraction, comparison of hydrochloric and nitric acid systems with TBP, 17: 10735 (JINR-P-1075)
**CALIFORNIUM ISOTOPES Cf-250**
fission of, energy and mass distribution and half life of spontaneous, 17: 11649 (UCRL-10481)
fission of, half life observations on, 17: 11649 (UCRL-10481)
**CALIFORNIUM ISOTOPES Cf-254**
fission of, energy and mass distribution and half life of spontaneous, 17: 11649 (UCRL-10481)
fission of, half life observations on, 17: 11649 (UCRL-10481)
**CALORIMETERS**
design of adiabatic, for radioactivity measurements, 17: 11023
design to measure stored energy in irradiated graphite, 17: 10974
**CALORIMETRY**
development of heat amplifiers, 17: 10849(R) (HW-73337(p.29-76))
**CAMBRIDGE SYNCHROTRON**
beam intensity and position measurement, 17: 11797 (TID-16967)
operation of, summary of Brookhaven-Yale research, 17: 11332(R) (TID-17590)
**CAMERAS**
testing of polaroid, for neutron image detection, 17: 10999 (ANL-FGF-340)
**CAPTURE-TO-FISSION RATIOS**
measurement in low-flux reactors by pile oscillator techniques, 17: 11963 (TID-17738)
**CARBAMIC ACID, DITHIO-**
protective effects against radiation damage in *Escherichia coli* and mice, 17: 10428
**CARBAMIC ACID ESTERS**
protective effects against radiation damage in *Escherichia coli* and mice, 17: 10428
**CARBAMIC ACID, ETHYL ESTER**
effects on immunological recovery in mice, role of thymus in, 17: 10412
**CARBINOLS**
production by photoreduction of benzophenone, effects of retarders on, 17: 10680(R) (TID-17584)
**CARBON**
bonding with fluorine in organic compounds, nuclear magnetic resonance spectra of, 17: 11356
bremsstrahlung reactions (γ,p) at 335 Mev, 17: 11704
corrosion and transport of, in high-temperature gas cooled reactors, 17: 11981 (GA-2630)
deuteron scattering at 3 to 30 Mev, optical model analysis of, 17: 11676
diffusion in niobium and vanadium steels, 17: 11209
melting experiments, 17: 11201(T) (AEC-tr-5598)
meson ($\pi^-$) capture by, single charged particle emission in, 17: 11679
reactions with boron and cerium oxides, 17: 10662
**CARBON DIOXIDES**
distillation of primary and secondary amines with, isotope effects in, 17: 10521
heat transfer properties, 17: 11969
production in photodecomposition of organic acids sensitized by uranyl chloride, 17: 10697
reactions with hot tungsten surface at 1710 to 2500°K, energy exchange in, 17: 10609 (UCRL-10504)
**CARBON ISOTOPES**
equilibria in systems of carbon dioxide with primary and secondary amines, 17: 10521
**CARBON ISOTOPES C-11**
production in carbon-12 (p,pn) reaction, cross sections for, 17: 11663
radiation and scavenging effects on reactions with cyclohexane, yields in,

17: 10701
**CARBON ISOTOPES C-12**
alpha inelastic scattering at 14 Mev, 17: 11612 (AFOSR-2975)
alpha reactions (α,n), threshold of, 17: 11715
bremsstrahlung reactions (γ,p) at 31 Mev, spectrum from, 17: 11749
deuteron reactions in, nitrogen-14 excited states from, 17: 11623 (NP-12496)
electronic charge distribution at high energy, 17: 11388
energy levels, 17: 11693
gamma reactions (γ,n) and (γ,np) on, cross sections for, 17: 11672
gamma reactions (γ,n) at 30.5 Mev, neutron spectra from, 17: 11755
lithium nucleus reactions (lithium-6), 17: 11718
meson ($\mu^-$) capture by, 17: 11541
meson ($\pi^-$, $\pi^-$n) reactions at 53 to 1610 Mev, cross sections and excitation functions for, 17: 11650 (UCRL-10531)
meson ($\pi^-$) reactions with, excitation function and study of mechanisms for, 17: 11648 (UCRL-10312)
neutron elastic scattering by, polarization in fast, 17: 11741
nucleon momentum distribution in, 17: 11695
proton inelastic scattering by, dipole-resonance effects on, 17: 11734
proton quasi-elastic scattering by, 17: 11736
proton reactions (p,α), boron-9 excited state production in, 17: 11683
recoil range and charge-distribution from deuteron bombardment of, measurement of, 17: 11634(R) (TID-17696)
**CARBON ISOTOPES C-13**
measurement of variations of, in nature, 17: 10243 (NP-12381)
proton reactions (p,γ), 17: 11714
**CARBON ISOTOPES C-14**
age measurements with, 17: 10243 (NP-12381)
determination of, in gas-liquid chromatographic effluents by scintillation, flow-through method for, 17: 11027
isotope effects of, measurement by a differential method, 17: 10510(R) (ORNL-3320(p.47-55))
use in age measurements, laboratories for, 17: 10834
**CARBON MONOXIDES**
reactions with niobium pentoxide, 17: 10661
reactions with oxygen, mechanisms of, 17: 10240(R) (NP-12208)
**CARBON STEEL**
radiation effects on, neutron, 17: 11287
**CARBON SYSTEMS**
C–Nb–W–Zr, extrusion of tubing from, optimization studies, 17: 11140(R) (AMC-TR-7-775(VII))
C–U, fabrication and irradiation testing, 17: 11110(T,R) (EURAEC-387)
**CARBON TETRACHLORIDE**
chemical effects on solvent extraction of uranyl sulfate using tri-n-octylamine, 17: 10756
radiation effects on polyisobutylene and polystyrene in solutions of, 17: 10709
thermoelectric effects on nickel and platinum, 17: 11435
$CCl_4$–$Cl_2$, corrosive effects on nickel alloys, 17: 10246(R) (ORNL-TM-403)
**CARBON TETRAFLUORIDE**
stability of, radiation and thermal effects on, 17: 10516 (ORNL-TM-475)
**CARBONIUM COMPOUNDS**
formation in radiolysis of diisopropyl ether, dose rate and temperature effects on, 17: 10705
**CARCINOMAS**
detection of bone metastases from breast, by external scanning after administration of calcium-47 or strontium-85, 17: 10344
radiotherapy of gynecological, late effects from, 17: 10372
radiotherapy of uterine cervix, complications in, from supervoltage and telecobalt, 17: 10449
radiotherapy of uterine cervix, complications from, 17: 10496
radiotherapy of uterine cervix, dosimetry of vaginal smear in, 17: 10259
use of yttrium-90 for therapy of breast, histological effects of, on pituitary gland, 17: 10451
**CARDIOGRAPHY**
instrument for recording changes in radio-, design of, 17: 11024
**CAROLINAS-VIRGINIA TUBE REACTOR**
development, 17: 11996(R) (WCAP-4125)
development, 17: 11997(R) (WCAP-4131)
**CASCADE IMPACTORS**
design of five-stage, for operation at low flow rates, 17: 10775 (LF-5)
**CASTING**
development of, for reactor fuel fabrication, 17: 11123
**CATALASES**
radiation effects on accumulation of, in conidia of *Aspergillus niger*, 17: 10397
**CATION EXCHANGE MATERIALS**
relations between cesium and base cation exchange on, 17: 10583 (HW-SA-2452)
solvent properties of Dowex 50W X8 for metals from acetone–hydrochloric acid aqueous solutions, 17: 10733 (IS-466)
use of weakly acidic, for pH control in high-pH aqueous systems, 17: 10499 (HW-SA-2595)
**CATS**
localization of brain tumors in, using iodine-131-labeled polyviaylpyrrolidone, 17: 10287
**CATTLE**
radiation effects on growth and sexual development in, exposed *in utero*, 17: 10422
**CAVITY RESONATORS**
instrumentation, 17: 11819
loading of, in accelerators, 17: 11792 (RT/EL(62)15)
tuning of, phase discriminator for, 17: 11791 (RT/EL(62)14)
**CERAMIC MATERIALS**
coating with niobium, 17: 11116(T) (EURAEC-487)
development, 17: 11129
mechanical properties of porous, 17: 11226
properties of, summary of, 17: 11119(T) (JPRS-17322)
radiation effects, 17: 11125
use for absorption of radioactive wastes, 17: 12052 (TID-7646(p.94-101))
**CERIUM**
determination in aluminum as trace impurity, activation, 17: 10546
distribution between bismuth–magnesium alloy and magnesium chloride–potassium chloride–sodium chloride eutectic at 500°C, 17: 10581 (BNL-639)
separation from aqueous solutions by solvent extraction with thorium using TBP, 17: 10760
**CERIUM ALLOYS**
Ce–Cu–Pu, phase studies, 17: 10239(R) (MLM-1140)
Ce–Y, phase studies, 17: 11186 (DRI-2080)
**CERIUM CARBIDES**
free energy of formation of mono-, standard, 17: 10644
**CERIUM ISOTOPES Ce-137**
nuclear alignment of, 17: 11705
nuclear magnetic moment, 17: 11705
**CERIUM ISOTOPES Ce-139**
nuclear alignment of, 17: 11705
nuclear magnetic moment, 17: 11705
**CERIUM ISOTOPES Ce-140**
carbon nucleus reactions with, measurements of various parameters of, 17: 11645 (UCRL-10099)
neutron capture cross section and resonance integral, 17: 10506(R) (ORNL-3320(p.1-15))
**CERIUM ISOTOPES Ce-141**
neutron capture cross section, 17: 10506(R) (ORNL-3320(p.1-15))
nuclear alignment of, 17: 11705
nuclear magnetic moment, 17: 11705
**CERIUM ISOTOPES Ce-143**
decay scheme, 17: 11689
nuclear alignment of, 17: 11705
nuclear magnetic moment, 17: 11705
**CERIUM ISOTOPES Ce-144**
beta decay of, matrix elements ratio for, 17: 11664
removal of internally deposited, evaluation of chelating agents, 17: 10333
separation from praseodymium-144, carrier-free, 17: 10762
**CERIUM NITRATES**
toxic effects in rats, sex difference, 17: 10484(R) (NP-12251(p.90-8))
**CERIUM OXIDES**
$B_2O_3$–$CeO_2$, reduction by carbon, 17: 10662
**CERIUM SELENIDES**
thermoelectric properties, 17: 11296 (AD-278352)
$Ce_3Se_4$–$Sr_3Se_4$, thermoelectric properties, 17: 11296 (AD-278352)

**CERIUM SULFATES**
oxidation of hydrogen peroxide by, kinetics of, 17: 10631
**CERIUM TELLURIDES**
thermoelectric properties, 17: 11296 (AD-278352)
$Ce_xTe_x-Sr_xTe_x$, thermoelectric properties, 17: 11296 (AD-278352)
**CERIUM VANADATES**
structure of, x ray diffraction analysis of, 17: 10663
**CERMETS**
radiation effects on clad uranium-dioxide, 17: 11254 (BMI-1608)
**CESIUM**
adsorption of lanthanides by inorganic ion exchange materials, 17: 10740(R) (ORNL-TM-181)
corrosive effects on metals at 1290 to 1830°F, 17: 11129
determination in aluminum as trace impurity, activation, 17: 10546
determination in potassium and sodium salts, spectrometric, 17: 10565
diffusion of, in glass, activation energy and coefficient of, 17: 10642
electric discharge in vapor of, in diodes, 17: 11441
exchange reactions on clinoptilolite, relations with base cations, 17: 10583 (HW-SA-2452)
nuclear quadrupole resonance, 17: 10592 (IS-520)
performance of diodes of, in parallel-series circuits, 17: 11315 (NAA-SR-7661)
plasma oscillations in, near ion cyclotron frequency, 17: 11851
separation from aqueous solutions using nitrobenzene in presence of sodium tetraphenyl borate, 17: 10757
separation from aqueous solutions using nitrobenzene, mechanism of, 17: 10759
separation from basic solutions by solvent extraction using dipicrylamine, 17: 10731 (HW-SA-2620)
solvent extraction from purex wastes, 17: 10739(R) (ORNL-TM-27)
solvent extraction from purex wastes, flowsheet for, 17: 10740(R) (ORNL-TM-181)
thermionic emission of rhenium in vapor of, 17: 11346
thermionic emission of, on refractory-metal electrodes, 17: 11347
**CESIUM CHLORIDES**
radiolysis effects on yields in liquid methanol, 17: 10699
thermodynamic properties at 0 to 300°K, 17: 10584 (BM-RI-6157)
**CESIUM IODIDES**
thermodynamic properties at 0 to 300°K, 17: 10584 (BM-RI-6157)
**CESIUM ISOTOPES $Cs^{+}$-132**
decay scheme, 17: 10506(R) (ORNL-3320(p.1-15))
**CESIUM ISOTOPES $Cs^{+}$-134**
enrichment of solutions of, by foaming, 17: 10706
**CESIUM ISOTOPES $Cs^{+}$-137**
determination in milk by beta counting, 17: 10551
determination in water, radiochemical, 17: 10850(R) (HW-73337(p.77-157))
gamma emission from, calculation of attenuation in lead, 17: 11904
metabolism in rats, effects of dietary level of sodium and potassium, 17: 10310(R) (TID-17789)
packaging of, by absorption on Zeolite, thermal conditions for, 17: 12040 (HW-74712)
use in nondestructive testing of steel, 17: 10817
**CESIUM ISOTOPES $Cs^{+}$-138**
gamma emission by, abundance of 1.43 Mev, 17: 11621 (KAPL-M-HME-6)
**CESIUM NITRATES**
salting-out properties in uranyl nitrate extraction from aqueous solutions, 17: 10770
**CHALKS**
radioresistance effects on insulating silicate-filled rubber vulcanizates, 17: 11286
**CHARGED PARTICLE BEAMS**
acceleration of secondary, design of magnet systems for, 17: 11790 (PPAD-459F)
containment of external accelerator, design of channel for, 17: 11789 (NYO-10251)
control of, automatic closed-orbit system for, 17: 11811(T) (NP-tr-932)
control of, computer program for, 17: 11781 (BNL-6189)
focusing in cylindrically symmetric magnetic fields, 17: 10935
interactions with a plasma in the presence of a magnetic field, instabilities resulting from, 17: 11863
measurement of, method for, 17: 11782 (BNL-6645)
production of polarized, use of metastable states of atoms in, 17: 11640(R) (TID-17720(p.79-89))
transport systems for, synthesis of mirror-symmetric, 17: 11802 (TID-17661)
**CHARGED PARTICLES**
Coulomb interaction in plasma, 17: 11869
diffusion across magnetic fields in positive-column plasma, 17: 11868
diffusion of dense plasma in magnetic field, 17: 11880
distribution function of, in quantum-mechanical phase space, 17: 11927
equation of state of classical systems of, 17: 11497 (UCRL-6450-T (Rev.I))
injection into magnetic fields, 17: 10240(R) (NP-12208)
interactions of, Regge trajectories for relativistic, 17: 11470 (JINR-E-1116)
interactions with electron plasma, 17: 11867
localizability of quantum mechanical systems of, 17: 11929
motion in accelerators, computer for analyzing, 17: 11773 (BNL-767 (p.145-60))
motion in accelerators, phase-locked oscillator analog for studying, 17: 11774 (BNL-767(p.161-71))
motion in cylindrically symmetric magnetic focusing magnetic fields, 17: 10935
motion in electric discharges in vacuum, 17: 11886
motion in field of tapered solenoid, 17: 11795 (SLAC-4)
motion in periodic fields, 17: 11822
motion of axially symmetric systems of, equations for, 17: 11887
polarization of low-energy, equipment for analyzing, 17: 11815
processes in systems of, theory of irreversible, 17: 11832 (MATT-106)
ranges in materials, fabrication of plastic films for measuring, 17: 10911 (TID-16251)
retardation of non-relativistic, effects of polarization on, 17: 11341
scattering amplitudes of, analytic properties of partial-wave, 17: 11572
scattering from collective states of nuclei, 17: 11699
**CHEMICAL ANALYSIS**
use of, in mass determinations, sources of error in, 17: 10614
**CHEMICAL ENGINEERING**
evaluation of reduced-pressure backflow preventer, 17: 10515 (ORNL-3380)
**CHEMICAL PROPHYLAXIS**
of radiation injuries, 17: 10477(R) (NP-12251)
of radiation injuries of enzyme systems in spleen, thymus, and intestine, 17: 10480(R) (NP-12251(p.22-33))
of radiation injuries, evaluation of 46 compounds, 17: 10481(R) (NP-12251(p.34-46))
of radiation injury to cells in tissue culture, 17: 10491
of radiation injuries in cells in tissue cultures, 17: 10493
**CHEMICAL RADIATION DETECTORS**
development of, from 1958 to 1962, review, 17: 10998 (AERE-R-4189)
performance of oxalic acid, 17: 11030
**CHEMISTRY**
branching stochastic processes in, theory of, 17: 10520(T) (NP-tr-946)
**CHICKENS**
radiation effects on growth, comparison of gamma and x rays, 17: 10471
radioinduced sterilization in female and male embryos, 17: 10375
**CHIMERAS**
immunological factors in radiation, 17: 10474
radiation, effects on injected lymph node cells, 17: 10473
radiation, immunological tolerance to bone marrow and fetal liver cells in, 17: 10270
**CHLORAL**
crystal structure, 17: 10514(R) (ORNL-3320(p.104-25))
**CHLORATES**
magnetic resonance of irradiated, 17: 10514(R) (ORNL-3320(p.104-25))
nuclear quadrupole resonance, 17: 10592 (IS-520)
**CHLORIDE COMPLEXES**
with cadmium ion in concentrated aqueous solutions of ammonium nitrate, formation constant, 17: 10594 (TID-15741)
with hexavalent neptunium, plutonium, and uranium, anion exchange and nonaqueous studies, 17: 10585 (HW-SA-2596)
**CHLORIDES**
nuclear quadrupole resonance, 17: 10592 (IS-520)
sorption by intestine and stomach in dogs, effects of centimeter band

radio waves on, 17: 10315
**CHLORINE**
activating effects on luminescence of copper-activated zinc sulfide phosphor, 17: 11228(T)
nuclear quadrupole resonance, 17: 10592 (IS-520)
$CCl_4$–$Cl_2$, corrosive effects on nickel alloys, 17: 10246(R) (ORNL-TM-403)
**CHLORINE ISOTOPES Cl-35**
proton reactions (p,n), threshold of, 17: 11715
**CHLORINE ISOTOPES Cl-38**
decay of isomeric, 17: 11747
half life, 17: 11628 (TID-15849)
**CHLOROFORM**
chemical effects on solvent extraction of uranyl sulfate using tri-n-octylamine, 17: 10756
reactions with pyrroles, 17: 10668(T) (NP-tr-941)
**CHLOROPLASTS**
protein synthesis in, tracer studies of role of lipoproteins in, 17: 10314
radiation effects on extracts and fragments of, 17: 10458
**CHOLANTHRENE, 3-METHYL-**
leukemia induced in rats by x radiation and, transmission of, 17: 10258
**CHROMATES**
formation of hexavalent, by oxidation of trivalent chromium in molten chlorides, 17: 10518(R) (TID-17823)
**CHROMATOGRAPHY**
combination of gas, with mass spectrography, 17: 10558
design and performance of apparatus for gas, 17: 10955
development of apparatus for thin layer, 17: 10926
radioactivity on two-dimensional paper chromatograms, design of semiautomatic device for measuring, 17: 10543
use of gas, for production of rare gases, 17: 10954
**CHROMIUM**
alloying effects on hardness of beta-quenched uranium, 17: 11097(R) (NMI-7257)
determination in alloys, 17: 10539 (TID-16296)
determination in aluminum as trace impurity, activation, 17: 10546
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
diffusion in beta uranium, 17: 11079 (ANL-FGF-334)
dissolution rate in liquid aluminum, 17: 10577 (ANL-FGF-292)
separation from metal ionic mixtures, electrochromatographic, 17: 10753
Cr–$HBF_4$–HF–$HNO_3$–Zr, solvent properties for uranium–zirconium alloy, 17: 10246(R) (ORNL-TM-403)
**CHROMIUM ALLOYS**
Cr–Nb, corrosion by liquid sodium, 17: 11935(R) (ANL-6658)
Cr–Nb–Ti, phase studies at 600, 800, and 1000°C, 17: 11212
Cr–Nb–Zr, phase studies, 17: 11108(T,R) (EURAEC-307)
Cr–Tc, phase studies on, 17: 11220
Cr–Zr, structural study, 17: 11108(T,R) (EURAEC-307)
**CHROMIUM BORIDES**
bibliography on preparation and properties of, 17: 10579 (ASD-TDR-62-873)
fabrication by pressing and sintering powders, 17: 11170(T) (AEC-tr-5604)
**CHROMIUM IONS**
charge and radius effects of hydrated, on radiation stability of ion exchange resins, 17: 10719
oxidation of trivalent, 17: 10518(R) (TID-17823)
**CHROMIUM ISOTOPES Cr-50**
deuteron reactions (d,p) at 13.6 Mev, 17: 11742
proton scattering at 6.9 Mev, 17: 11656
**CHROMIUM ISOTOPES Cr-51**
gamma emission in man, method for measurement of, 17: 10271
**CHROMIUM ISOTOPES Cr-52**
deuteron reactions (d,p) at 13.6 Mev, 17: 11742
proton scattering at 6.9 Mev, 17: 11656
**CHROMIUM ISOTOPES Cr-53**
deuteron reactions (d,p) at 13.6 Mev, 17: 11742
nuclear spin, hyperfine interaction, 17: 11299(R) (ANL-6612)
proton scattering at 6.9 Mev, 17: 11656
**CHROMIUM ISOTOPES Cr-54**
deuteron reactions (d,p) at 13.6 Mev, 17: 11742
proton scattering at 6.9 Mev, 17: 11656
**CHROMIUM NITRATES**
salting-out properties in uranyl nitrate extraction from aqueous solutions 17: 10770
**CHROMIUM STEEL**
Cr–Ni, effects of niobium and zirconium on, 17: 11210
**CHROMIUM SYSTEMS**
Cr–Mo–$UO_2$, radiation effects on stainless steel-clad, 17: 11254 (BMI-1608)
**CHROMOSOMES**
breakage in salivary gland and sperm in Drosophila, natural and radio-induced, 17: 10403
radiation effects on, in blood cells and bone marrow from diagnostic radiography, 17: 10435
radiation effects on, in *Medicago sativa L.*, 17: 10398
radiation effects on, in *Medicago sativa L.*, 17: 10399
radiation effects combined with maternal age on non-disjunction of, in *D. melanogaster*, 17: 10400
radiation effects on kinetochore in hemiptera, 17: 10404
radioinduced aberrations in, in *Tradescantia* anthers, 17: 10454
radioinduced aberrations in grasshopper, effects of cysteamine treatment, 17: 10492
radioinduced aberrations in Drosophila, 17: 10415
radioinduced rearrangement of, in translocated heterozygotes of *Tipula oleracea*, 17: 10402
**CIRCUITS**
design of high-level linear gate, for pulse-height analyzers, 17: 11031
development of current-switching, 17: 10918 (UCRL-9035(Rev.))
development of triggered flip-flop, for computers, 17: 11069(R) (TID-17551)
review of two-condition flip-flop stages with complementary transistors, 17: 10921(T) (SCL-T-460)
**COAL**
measurement of pulverized, in pneumatic conveyers by beta transmission, 17: 10881(T) (AEC-tr-5581)
**COAXIAL CABLES**
theory of coaxial shunt, 17: 11334 (TID-17677)
**COBALT**
alloying effects on copper-zirconium alloys, 17: 11225
determination in alloys, 17: 10539 (TID-16296)
determination in aluminum as trace impurity, activation, 17: 10546
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
determination of, spectrophotometric method using tricaprylmethyl-ammonium thiocyanate as selective extraction agent, 17: 10540 (TID-17745)
dissolution rate in liquid aluminum, 17: 10577 (ANL-FGF-292)
solubility in germanium crystals, 17: 10240(R) (NP-12208)
**COBALT BROMIDES**
properties in lithium-potassium nitrate eutectics, 17: 10605(R) (TID-17816)
properties in potassium-sodium nitrate eutectics, 17: 10605(R) (TID-17816)
**COBALT(II) CHLORIDES**
properties in lithium-potassium nitrate eutectics, 17: 10605(R) (TID-17816)
properties in potassium-sodium nitrate eutectics, 17: 10605(R) (TID-17816)
**COBALT COMPLEXES**
oxygen isotope exchange with oxygen (gaseous), 17: 10634
**COBALT(II) FLUORIDES**
properties in lithium-potassium nitrate eutectics, 17: 10605(R) (TID-17816)
properties in potassium-sodium nitrate eutectics, 17: 10605(R) (TID-17816)
**COBALT IONS**
separation from metal ions by extraction using 8-quinolinethiol, 17: 10768
**COBALT ISOTOPES Co-60**
distribution of inhaled particulate, in body, 17: 10849(R) (HW-73337 (p.29-76))
energy requirements for ion pair production in air, 17: 10849(R) (HW-

73337(p.29-76))
gamma emission, 1.17 and 1.33 Mev, 17: 11627 (TID-15088)
**COBALT URANATES**
properties and structure, 17: 10633
**COINCIDENCE CIRCUITS**
design and performance of fast-slow, modified to time to pulse-height converter, 17: 11033
design of transistorized, for decade counters, 17: 11021
**COLD NEUTRONS**
production of, equipment for, 17: 12032
scattering and slowing-down by hydrogenous compounds, 17: 11602
scattering by beryllium oxides, cross sections for, 17: 11671
scattering by vanadium, elastic and inelastic, 17: 12032
**COLLAGEN**
radiation effects in atrophic muscle, 17: 10465
**COLUMBIA RIVER**
analysis of silt and water, 17: 10850(R) (HW-73337(p.77-157))
**COMPRESSORS**
design for filling helium-3 detectors, 17: 10934
development of, for use in radiation-resistant pneumatic systems, 17: 10774(R) (GDC-63-001)
**COMPUTER PROGRAMS**
CALCOMP plotter subroutine for IBM-7090, 17: 11067 (ORNL-TM-430)
CASPER, for data plotting and scaling for Calcomp 570 plotter, 17: 11066 (ORNL-3394)
for analysis of complex beta spectra for IBM-704, 17: 11443
for solving Fick's second law in binary diffusion couples, 17: 11301 (ASD-TDR-62-858)
for three-region fully reflected cylindrical reactors, IBM-1620, 17: 11933 (AAEC/E-101)
HAFMAT, for analysis of flow systems, 17: 10798 (KAPL-M-LXW-1)
HARC, for heat transfer and reaction mechanism analysis, 17: 10606 (UCRL-7069)
HEART THROB, for heat transfer and reaction mechanism analysis, 17: 10606 (UCRL-7069)
HECTIC-II, for heat-transfer analysis of gas or liquid-cooled reactor passages on IBM-7090, 17: 10795 (IDO-28595)
HOTSTICK, for calculating axial power distribution in reactor core, 17: 11951 (KAPL-M-RPC-5)
KWIP, for calculating excess reactor reactivity, 17: 11950 (KAPL-M-EC-28)
PAKAG, for least-squares fit of functions on IBM-7090, 17: 11065 (LA-2367(Add.))
PROLOG, for long-range project planning, 17: 11073 (UCRL-10491)
RATH mesher, for preparing input data for heat conduction codes, 17: 10799 (LAMS-2809)
SCRAMBLE, for simulation of peripheral equipment on IBM 1401, 17: 11074 (XDC-61-5-2)
SORTIE I, for inelastic neutron scattering by Hauser Feshbach calculations, 17: 11591 (NP-12370)
THD2, for one-dimensional temperature distribution in slab with internal heat generation, 17: 10797 (KAPL-M-EC-27)
**COMPUTERS**
analog, for studying motion of particle in a proton synchrotron, 17: 11773 (BNL-767(p.145-60))
arithmetic unit control in, speed-independent logic for, 17: 11070 (TID-17653)
development of high-speed, 17: 11069(R) (TID-17551)
formula translation and combinatorial systems for, 17: 11064 (CERN-62-35)
operation of, schedules for Iliac and 7090 at Illinois University, 17: 11069(R) (TID-17551)
research program at University of Illinois, 17: 11071(R) (TID-17810)
use in analysis of noise measurement, 17: 10916 (TID-17788)
use in automatic closed-orbit beam control in accelerators, 17: 11811(T) (NP-tr-932)
**CONCRETE AGGREGATES**
shielding properties of, tests on, 17: 11218
**CONCRETES**
gamma backscattering from plane walls, 17: 11895 (AE-92)
gamma backscattering from spherical walls, 17: 11896 (AE-93)
gamma multiple scattering in spherical room, 17: 11897 (AE-94)
gamma scattering by, formulas for differential dose albedo in, 17: 11901 (NP-12455)
proton beam reactions in, meson and nucleon cascades from, 17: 11489 (ORNL-3367)
**CONFERENCES**
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**CONNECTIVE TISSUE**
radiation effects on collagen of, in rats, 17: 10465
**COPPER**
deformation in heat treatment, 17: 10240(R) (NP-12208)
determination in aluminum, x-ray spectroscopic, 17: 10571
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
etching by cathodic arc, 17: 11089 (HW-SA-2559)
heat of vaporization, 17: 10240(R) (NP-12208)
heat transfer by tubular, effects of impressed voltage on, 17: 10801(R) (NYO-10345)
nuclear quadrupole resonance, 17: 10592 (IS-520)
oxidation at high temperatures, mechanism of, 17: 11135(T,R) (EURAEC-483)
separation from metal ionic mixtures, electrochromatographic, 17: 10753
separation from trivalent iron by ion exchange chromatography, 17: 10752(T) (GAT-Z-5035)
solvent properties for zirconium in solid state, 17: 11240
spallation thresholds in, low-pressure, 17: 11326 (SC-4747(RR))
**COPPER ALLOYS**
Al–Cu, effects of cold working on phase segregation in, 17: 11246
Al–Cu, structure of martensitic beta prime phase, 17: 11195 (UCRL-9536)
Al–Cu–Mg, thermal capacity and conductivity at −180 to +200°C, 17: 11200 (USNRDL-TR-599)
Ce–Cu–Pu, phase studies, 17: 10239(R) (MLM-1140)
Cu–Au, conduction electron momentum in, electron–positron annihilation studies, 17: 11275
Cu–Au–Ag, restoration in deformed, 17: 10240(R) (NP-12208)
Cu–Ni, oxidation of, selective, 17: 11135(T,R) (EURAEC-483)
Cu–Ti, martensite transformations in, 17: 11239
Cu–Zr, age hardening and conductivity of, affect of oxidation inhibitors and purity on, 17: 11225
Cu–Zr, solid solubility of zirconium in copper in, 17: 11240
**COPPER CRYSTALS**
stress-strain curve for, temperature dependence of, 17: 11233
**COPPER FOILS**
neutron resonance integrals, 17: 11979(R) (DP-805)
**COPPER IONS**
charge and radius effects of hydrated, on radiation stability of ion exchange resins, 17: 10719
separation from metal ions by extraction using 8-quinolinethiol, 17: 10768

**COPPER ISOTOPES**
production in meson ($\pi^-$) reactions, cross sections and yields for, 17: 11650 (UCRL-10531)
**COPPER ISOTOPES Cu-64**
gamma emission, 0.51 Mev, 17: 11627 (TID-15088)
**CORROSION**
in nuclear power plants, review, 17: 11133 (TID-16561)
kinetics of fast interfacial reactions, analysis, 17: 10601 (TID-15942)
measurement techniques for, of metals in aqueous media, 17: 11135(T,R) (EURAEC-483)
**CORROSION INHIBITORS**
bibliography on, for high purity water, 17: 11137
**CORROSION LOOPS**
fabrication and testing of mercury, 17: 11131 (AGC-0584-04-5)
**CORTISONE**
effects on radiation damage to kidneys and submaxillary glands of rats, 17: 10470
**COSMIC ELECTRONS**
density of, at 1000 km, 17: 11452
density of, perturbation by satellites, 17: 11451
**COSMIC PARTICLES**
reactions on nuclei at 2300 m, mesons ($\pi^+$) from, 17: 11454
variation in air showers, isotropy in time, 17: 11450
**COSMIC RADIATION**
bibliographies on, 17: 11457
biological effects of heavy, in man, 17: 10353 (BNL-6098)
biological effects of heavy nuclei from, on mammalian skin, 17: 10363(R) (TID-17676)
effects on meteorites, 17: 11448 (BNL-6545)
generation in nebulae, thermodynamic analysis of, 17: 11456
intensity variations in, relation to geomagnetic disturbances, 17: 11455
nature of, 17: 10841
**COSMIC-RAY SPECTRA**
thermodynamic properties of, 17: 11456
**COSMIC SHOWERS**
particle time variations in, 17: 11450
**COUNTING DEVICES**
coincidence technique for decade, in transistor circuits, 17: 11021
comparison of binary and ring, 17: 11020
design of, for data logging uses, 17: 10903 (ORNL-TM-344)
design of summation-type, for detection of weak signals, 17: 10917 (UCRL-6832)
**CRITICAL ASSEMBLIES**
development of ZPR III, 17: 11935(R) (ANL-6658)
development of ZPR-VII, 17: 11935(R) (ANL-6658)
development of ZPR, 17: 11936(R) (ANL-6672)
**CRITICALITY STUDIES**
calculation of critical dimensions by zone loading technique, 17: 11461 (TID-17817)
eigenvalue matrix solution to N-component neutron interaction problems in arrays of neutron emitters, 17: 11458 (HW-75887)
mass calculation for cylindrical reactors in case of anisotropic diffusion coefficient, 17: 11463
neutron distribution and size calculations for critical system, use of Monte Carlo method in, 17: 11462 (UCRL-6707)
nuclear safety for, 17: 10528 (ANL-6637(p.43-57))
of hydrogen-moderated fully reflected spheres of plutonium, effects of scatterers on, 17: 11303(R) (HW-75228)
of plutonium nitrates, plutonium-239, and uranium-235 in aqueous solutions, 17: 11303(R) (HW-75228)
of water-moderated uranium hexafluoride cylinders, 17: 11460 (TID-17633)
on plutonium nitrate solutions, 17: 11459 (HW-SA-2432(Rev.))
review of recent, 17: 12011
**CRYSTAL STRUCTURE**
lattice parameter calculation from diffraction data for tetragonal structures, 17: 11330 (TID-16045)
of binary and ternary transition metal alloys, 17: 11180 (ANL-FGF-337)
**CRYSTALS**
analysis for uranium, fission, 17: 10555
atom channeling in, at 10 kev, 17: 11348
energy levels of rare earths in cubic sites in, 17: 10636
energy spectra of isotopic impurities in, 17: 11410
gamma absorption and emission by nuclei in, phonon effects on, 17: 11658
grain boundary and lattice diffusion effects in poly-, method for separation of, 17: 11236
neutron resonance absorption in, effects of grain structures on, 17: 11604
neutron scattering by, effects of four-phonon interactions on energy distributions in, 17: 11510
neutron scattering by impurity centers of, theory of magnetic, 17: 11511
radiation effects on, averages of primary recoil distributions in, 17: 11750
radiation emission from, external field effects on, 17: 11386
spin ordering in rare-earth, effects on electric conductivity, 17: 11413
structural analysis of covalent, ionic, and metallic, 17: 10664
**CURIUM**
solvent extraction using thenoyltrifluoroacetone, synergistic effects of tributyl phosphate and trioctylphosphine oxide, 17: 10729 (BNL-6188)
transfer from plasma to milk in sheep, tracer study, 17: 10326
**CURIUM ISOTOPES Cm-241**
fission of, energy and mass distribution and half life of spontaneous, 17: 11649 (UCRL-10481)
**CYANIDES**
protective effects against radiation injuries in mice, reaction mechanisms, 17: 10482(R) (NP-12251(p.47-66))
**CYANOGEN**
radiolysis of, in hydrogen, 17: 10509(R) (ORNL-3320(p.30-46))
**CYCLOHEXANE**
radiation and scavenging effects on reactions with recoil carbon-11, yields in, 17: 10701
radiolysis by carbon-12 (γ,n)-activated carbon-11 in, 17: 10675 (IS-425)
**CYCLOPROPANE**
reactions with mercury, effects of deuterium on quenching cross sections in, 17: 10685
**CYCLOTRON RADIATION**
emission by hot plasma, 17: 11849
**CYCLOTRONS**
design, characteristics, and testing of Berkeley 88-inch, 17: 11808 (UCRL-10081)
development of University of Michigan 83-inch spiral-ridge, 17: 11806(R) (TID-17735)
effects on peripheral blood vessels in workers, 17: 10444
ion acceleration and extraction in, with azimuthally varying magnetic field and regulated energy, 17: 11778 (BNL-767(p.254-77))
ion beam energy spread in, use of diaphragms for improving, 17: 11780 (BNL-767(p.288-92))
ion bunch duration and recurrence in, decrease of, 17: 11779 (BNL-767(p.278-87))
particle losses in isochronous, due to dissociation, 17: 11799 (TID-17617)
performance with multicharged ions, 17: 11818
**CYLINDERS**
bremsstrahlung absorption in, energy losses in, 17: 11585
charge distribution in conducting hollow, 17: 11432
electric conducting of hollow, mathematical analysis of, 17: 11433
neutron ages in, from point epithermal sources, 17: 10833
**CYSTEINE**
protective effects against radiation injury, 17: 10480(R) (NP-12251 (p.22-33))
protective effects against radiation injury to cells in tissue culture, 17: 10491
protective effects against phosphatase inhibition by ultraviolet radiation, 17: 10405
**CYTOCHROME OXIDASE**
radiosterilized diet effects on activity of, in liver in successive rat generations, 17: 10350

## D

**DATA RECORDING SYSTEMS**
code for use in making graphs with CALCOMP plotter, 17: 11067 (ORNL-TM-430)
design for Shippingport plant, 17: 10920 (WAPD-T-1447)
design of analog circuits for, 17: 10903 (ORNL-TM-344)
design of, for fuel element dimensions, 17: 10893 (HW-75746)

development of, for Hanford reactors, 17: 11946 (HW-SA-2549)
development of punched card system for personnel dosimetry information, 17: 10852(R) (HW-73337(p.238-97))

**DATA TABULATIONS**
cross sections and excitation energies for gamma and neutron reactions in reactors, 17: 11619 (CEA-2172)
elastic interactions of high-energy particles, 17: 11507
exchange intergrals between functions of K or L and O shells for equal nuclear charge, 17: 11344
neutron resonances in hafnium isotopes, 17: 11805(R) (TID-17728)
of nuclear quadrupole interactions and resonance frequencies in elements and inorganic compounds, 17: 10592 (IS-520)
on neutron cross sections, 17: 11613 (BNL-768)

**DECONTAMINATING SOLUTIONS**
performance for type 304 stainless steel, 17: 11959 (TID-15779)

**DECONTAMINATION**
equipment and procedures at Marcoule, 17: 10761
of reactor components, development of methods and reagents for, 17: 12042 (MSAR-61-34)
procedures in event of radiation accidents, medical, 17: 10876

**DELAYED NEUTRONS**
analytical uses, 17: 10534 (IA-784)
effects on shape of distribution curve of reactor, 17: 11949 (IFK-2)

**DENSITY**
measurement in solutions by beta ray absorption, 17: 10901 (NP-12390)
measurement in uranyl nitrate solutions, design of instrument for, 17: 10972

**DETONATION WAVES**
propagation in atmosphere, 17: 10837

**DEUTERIUM**
determination in heavy water-water systems, 17: 10240(R) (NP-12208)
determination in water, falling-drop, 17: 10566
equilibrium solubility in palladium–platinum alloys, 17: 10632
exchange with hydrogen in phenyl- and *p*-tolyl 2-octyl-2-d-sulfones, base catalyzed, 17: 10670
isotope effects of, measurement by a differential method, 17: 10510(R) (ORNL-3320(p.47-55))
neutron production in plasma of, 17: 11866
nuclear quadrupole resonance, 17: 10592 (IS-520)
oxidation on rotating disk electrode, limiting diffusion and ionization currents for, 17: 10628
quenching cross section effects on hydrocarbons, 17: 10685
separation from deuterium hydride and hydrogen on activated alumina, chromatographic, 17: 11057

**DEUTERIUM HYDRIDES**
acceleration in synchrotrons, 17: 11818
separation from deuterium and hydrogen on activated alumina, chromatographic, 17: 11057

**DEUTERON BEAMS**
biological effects of 22-Mev, in mice, 17: 10353 (BNL-6098)
reactions with hydrogen molecules, 17: 10514(R) (ORNL-3320(p.104-25))

**DEUTERONS**
acceleration in Brookhaven AGS, experiments with, 17: 11784 (BNL-6673)
bremsstrahlung reactions ($\gamma$,n), neutron polarization in, 17: 11551
capture by silicon-28 and tungsten-186, radiative, 17: 11634(R) (TID-17696)
gamma reactions ($\gamma$,n), neutron polarization in, 17: 11805(R) (TID-17728)
interactions with deuterons, helium-3 production in, 17: 11467 (IKF-4)
interactions with electrons with low momentum transfer, elastic, 17: 11505
interactions with tritons at 5 to 12 Mev, neutron spectra from, 17: 11526
interactions with protons, slightly inelastic, 17: 11540
photodisintegration of, electromagnetic transitions for, 17: 11531
production in meson ($\pi^-$) capture in emulsion, 17: 11679
reactions (d,$\alpha$) on aluminum-27, statistical model for, 17: 11675
reactions (d,n) with fluorine-19 at 1.0 and 1.3 Mev, 17: 11636(R) (TID-17720(p.8-14))
reactions (d,n) with boron-11, nuclear polarization in, 17: 11637(R) (TID-17720(p.15-37))
reactions (d,p) with chromium isotopes at 13.6 Mev, 17: 11742
reactions in carbon-12, nitrogen-14 excited states from, 17: 11623 (NP-12496)
reactions on holmium-165, energy levels of holmium-166 from, 17: 11729
reactions with boron-11 at 1.6 to 2.7 Mev, cross sections for, 17: 11693
reactions with carbon, charge-states and ranges of low-energy recoils from, 17: 11634(R) (TID-17696)
reactions with titanium-47, cross sections and excitation functions for, 17: 11624 (NYO-10386)
reactions with uranium-238 at 23 Mev, energy release in fission, 17: 11646 (UCRL-10193)
reactions with yttrium-89, isomer yield from, 17: 11634(R) (TID-17696)
scattering by aluminum-27 at 12.8 Mev, angular distributions and cross sections for elastic and inelastic, 17: 11625 (PAN-204)
scattering by light nuclei, 17: 10240(R) (NP-12208)
scattering by, nickel-58 and -60 at 12.8 Mev, cross sections for, 17: 11688
scattering by nuclei at 3 to 30 Mev, optical model analysis of elastic, 17: 11676
stripping in a Coulomb field, classical description of, 17: 11630 (TID-15924)

**DIAMONDS**
radiation coloring, 17: 11288

**DIAPHRAGMS**
development for use in pneumatic actuators, 17: 10889 (AD-252467)

**DIELECTRICS**
electromagnetic wave scattering by cylindrical, 17: 11856

**DIES**
development of materials for high-temperature, 17: 11081(R) (ASD-TR-7-886(Vol.VII))

**DIET**
analysis of U. S. for radium-226 content, 17: 10530 (ANL-6637 (p.85-95))
effects on radiation injuries of blood vessels, 17: 10485(R) (NP-12251(p.99-113))
radiosterilization of, effects on cytochrome oxidase and growth of successive rat generations, 17: 10350

**DIETHYLAMINE**
distillation of, with carbon dioxide, isotope effects in, 17: 10521

**DIFFUSION**
ion-atom interactions in gaseous, scattering and charge exchange cross sections for, 17: 11340(T) (AEC-tr-5615)
phenomenology of isothermal, 17: 10648
solution of Fick's second law in couples, computer program for, 17: 11301 (ASD-TDR-62-858)
theory of, using random walks on plane nets containing internal traps, 17: 11907 (TID-15885)

**DIMETHYLAMINE**
distillation of, with carbon dioxide, isotope effects in, 17: 10521

**DIODES**
charge-storage, improving pulse rise time by cascading, 17: 10924
circuit analysis of tunnel, graphical and graphico-analytic methods for, 17: 10890 (ANL-6634)
snap off effect of cascaded, generating ultrashort pulses using, 17: 10924
testing of cesium electron-ion, 17: 11838(R) (TID-16990)

**DIPHENYLAMINE**
radiolysis of, formation of cation amine radicals in, 17: 10687

**DIPHENYLAMINE, 2,2′, 4,4′, 6,6′-HEXANITRO-**
solvent properties for cesium, 17: 10731 (HW-SA-2620)

**DISASTERS**
calculation of reactor accidents, 17: 11183 (AWRE-0-61/62)
medical procedures in event of, 17: 10876
procedures for handling, 17: 10855 (HW-SA-2609)
radiation death from plutonium, at Los Alamos, 17: 10874

**DISPLACEMENT GAGES**
transformer heads for, standardization of linear variable differential, 17: 10904 (SCTM-100-62-81)

**DISULFIDES**
effects on photoreduction of benzophenone, 17: 10680(R) (TID-17584)
protective effects against radiation injury in cells in tissue culture, 17: 10493

**DODECANE**

adsorption by rutile under dodecyl ammonium chloride-water solutions, effects of hysteresis angles on, 17: 11091(R) (MITS-49)
**DOGS**
distribution and excretion of inhaled plutonium-239, 17: 10321
distribution of plutonium-239 in skeleton, long-term study, 17: 10329
pathological effects of plutonium-239 in liver, 17: 10328
plutonium deposition in bones in, histopathological effects of, 17: 10346
sorptive capacity of intestine and stomach in, effects of centimeter band radio waves on, 17: 10315
toxic effects of inhaled plutonium-239, 17: 10322
toxic effects of plutonium-239, long-term study, 17: 10319
toxic effects of plutonium-239, long-term study, 17: 10320
**DROSOPHILA**
effects of natural and radioinduced lethals in population, 17: 10256(R) (TID-17699)
mutagenic effects of carbon-14- and tritium-labeled DNA precursors on *melanogaster* males, 17: 10401
radiation effects on "brown spot" character of, x, 17: 10379
radiation effects on fitness factors in population of, 17: 10384
radiation effects combined with maternal age on non-disjunction of chromosomes in, 17: 10400
radiation effects, genetic, 17: 10415
radiation effects on survival of, 17: 10277
radioinduced chromosome breakage in salivary gland and sperm in, compared with natural, 17: 10403
radioinduced recessive lethals in, combined uv and x, 17: 10393
radioinduced sex-linked recessive lethals in, 17: 10392
**DRUGS**
effects of methysurgide, cysteamine, and 5-hydroxytryptamine on barbiturate response in irradiated rats, 17: 10418
preparation of labeled, by activation, 17: 10683
stimulating, effects on radiation injury in central nervous system in mice, 17: 10263
**DRY BOXES**
disassembly of plutonium–contaminated, 17: 10866 (TID-16203)
helium purification system for, 17: 10772 (ANL-6652)
**DYSPROSIUM**
reactions with ammonium nitrate and oxalate and potassium and sodium sulfates, precipitation, 17: 10621
**DYSPROSIUM CHLORIDES**
paramagnetic spin-lattice relaxation of hydrated, at 1.1 to 4.2°K, 17: 10652
**DYSPROSIUM ISOTOPES Dy-156**
neutron emission from compound nuclei of, angular momentum effects on, 17: 11645 (UCRL-10099)
**DYSPROSIUM SELENIDES**
thermoelectric properties of sesqui-, 17: 11292 (AD-277043)
$Dy_2Se_3$–$Dy_2Te_3$, thermoelectric properties, 17: 11292 (AD-277043)
**DYSPROSIUM TELLURIDES**
thermoelectric properties of sesqui-, 17: 11292 (AD-277043)
$Dy_2Se_3$–$Dy_2Te_3$, thermoelectric properties, 17: 11292 (AD-277043)

# E

**EARTH**
age estimation, review of methods for, 17: 10841
**EARTHQUAKES**
long-range seismic measurements of New Madrid, event on Feb. 2, 1962, 17: 10825 (NP-12465)
**EINSTEINIUM ISOTOPES Es-253**
fission of, energy and mass distribution and half life of spontaneous, 17: 11649 (UCRL-10481)
**ELASTICITY**
analysis of problems in thermoviscoelasticity, 17: 11338 (UCRL-13059)
**ELASTOMERS**
chemistry of, use of isotopes in, 17: 10691
**ELECTRIC ARCS**
axis temperature in, calculation of, 17: 11427
**ELECTRIC CONDENSERS**
development of, for thermonuclear reactors, 17: 11831(R) (LAMS-2816)
**ELECTRIC CONDUCTIVITY**
analysis in liquids, pressure, 17: 11364
measurement in uranyl nitrate solutions, design of instrument for, 17: 10972
of nonaqueous electrolytes, 17: 10504 (NYO-9696)
**ELECTRIC CURRENTS**
measurement in a pulsed toroidal gas discharge, design and performance of equipment for, 17: 10982
persistence in superconducting solenoids, 17: 11404
**ELECTRIC DISCHARGE**
breakdown voltages in homogeneous field with spark gaps from 7 to 30 cm, 17: 11426
charged particle motion in, in vacuum, 17: 11886
effects on diluted aqueous solutions, 17: 10717
electron and ion energy distributions in toroidal, 17: 11884
electron capture and ionization in, in gases, 17: 10240(R) (NP-12208)
in rarefied atmospheres, 17: 10902(R) (NYO-9676)
ion diffusion across magnetic fields in reflex, anomalous, 17: 11857
mechanism of electron-ion recombination in noble gases, 17: 11384
oscillations in cesium and mercury diodes, 17: 11441
particle diffusion across magnetic fields in positive columns of, 17: 11868
plasma oscillations in pulsed electrodeless, 17: 11892
probe theory for average and low pressure, 17: 11876
**ELECTRIC FIELDS**
effects on angular correlations of nuclear radiation, 17: 11386
**ELECTRIC POWER**
economics and prospects of nuclear, in EURATOM countries, 17: 10251
**ELECTRIC PROBES**
theory of, in plasma, 17: 11876
**ELECTROCHEMISTRY**
research programs with fused salts, 17: 10518(R) (TID-17823)
**ELECTRODES**
design for gamma and neutron logging in drill holes, 17: 10836
thermionic emission of cesium-coated refractory metal, 17: 11347
**ELECTRODYNAMICS**
charge distribution in hollow cylinders, 17: 11432
formulas for, of hollow cylinders, 17: 11433
generalization of Planck's radiation law in $A$-$e$-$J$ theory, 17: 11429
infrared singularities and Regge trajectories in, 17: 11470 (JINR-E-1116)
**ELECTROLYTES**
diffusion in, phenomenology of isothermal, 17: 10648
survey of conductance data on nonaqueous, 17: 10504 (NYO-9696)
**ELECTROLYTIC CELLS**
development for metal corrosion research, 17: 11135(T,R) (EURAEC-483)
**ELECTROMAGNETIC FIELDS**
frequencies of, for plasma containment, 17: 11845
quantization of, 17: 11911
**ELECTROMAGNETIC LENSES**
particle-focusing properties of cylindrically symmetric, 17: 10935
**ELECTROMAGNETIC WAVES**
absorption by classical and quantum plasma, 17: 11864
confinement and propagation in plasma waveguide, 17: 11828 (AFCRL-62-63)
coupling to MHD waves at plasma discontinuity, 17: 11850
deflection of, in cylindrical plasma columns, 17: 11827 (AD-277601)
diffraction of plane, mathematical analysis of, 17: 11434
propagation in cylindrical waveguide containing inhomogeneous plasma, 17: 11843
propagation in fully ionized plasma, 17: 11878
propagation in hydrogen plasma, 17: 11885
propagation in stationary plasma, 17: 11888
scattering by cylindrical dielectrics and plasma, 17: 11856
**ELECTRON BEAMS**
design and performance of "AdA" accumulator ring, 17: 11820
instrumentation, 17: 11798(R) (TID-17221)
interactions with plasma, oscillation spectra from, 17: 11871
light scattering by, 17: 11550
measurement of intensity and position in the Cambridge synchrotron, 17: 11797 (TID-16967)
microwave chamber heating by 800-Mev, 17: 11794 (SLAC-3)
**ELECTRON MICROSCOPES**
tilting stage for Hitachi H U-11, liquid helium cooled, 17: 10914 (TID-17744)

**ELECTRON MICROSCOPY**
technique for, of radioautograms of tritium-labeled biological materials, 17: 10284
use in nuclear reaction analysis, 17: 11615 (BNL-6082)
use in studying metal fractures, 17: 11083 (DMIC-Memo-161)
uses in analysis of fracture surfaces, 17: 11185 (D1-82-0169)
**ELECTRON MULTIPLIER TUBES**
development of resistance-strip magnetic, 17: 10898(R) (N62-10115)
**ELECTRON PAIRS**
production in photon-proton interactions, cross-sections for high-energy, 17: 11516
**ELECTRON SHOWERS**
development in microwave section of accelerators, 17: 11794 (SLAC-3)
**ELECTRON SOURCES**
development of cold, 17: 10898(R) (N62-10115)
**ELECTRON TUBES**
components of, standardization of, 17: 11019
**ELECTRONIC EQUIPMENT**
design for nuclear physics, 17: 11049
development of current-switching circuits for, 17: 10918 (UCRL-9035 (Rev.))
radiation effects on semiconductor, 17: 11267 (TID-15959)
**ELECTRONS**
acceleration in plasma, 17: 11771 (BNL-767(p.106-15))
acceleration of, in induction accelerator, method for, 17: 11824(P)
capture in betatron orbits, conditions for, 17: 11810 (USASRDL-TR-2257)
collisions of, with hydrogen atoms, effects of exchange and strong bond on cross sections for, 17: 11361(T)
currents of, classification of, 17: 11479 (LNF-62/98)
cyclotron radiation from free, line contours of, 17: 11538
densities in hydrogen plasmas, 17: 11860
density and temperature in mercury–neon plasma, 17: 11883
density distribution in plasma, 17: 11874
dielectric constant of degenerate gas of, 17: 11861
diffusion in plasma, 17: 11890
displacement of, from equilibrium orbit in betatron, method for, 17: 11825(P)
distribution in plasmas, 17: 11848
distribution in toroidal electric discharge, 17: 11884
drift velocity in argon and hydrogen, 17: 11430
effects on *Clostridium botulinum* spores in meat, effects of low temperatures on, 17: 10883
emission from metal surfaces by helium and hydrogen collisions, 17: 11397
emission from solids, effect of band structure on thermionic, 17: 11336 (UCRL-6820)
interactions in strong magnetic field, Coulomb, 17: 11538
interactions in superconductors, analysis of, 17: 11482 (NP-12435(Pt.II))
interactions with deuterons with low momentum transfer, elastic, 17: 11505
interactions with protons, weak-transfer elastic, 17: 11506
interactions with protons, meson ($\pi$) production by, 17: 11543
interactions with polarized photons, 17: 11549
ionization by, crossed-beam method of measuring cross-section for, 17: 11319 (NP-12358)
ionization of atomic hydrogen by, calculation of S-cross section for, 17: 11359(T)
magnetism of free gas of, perturbation series for calculating, 17: 11584
multiplication of secondary, test of theory for, 17: 11576
oscillations in stationary plasma, longitudinal, 17: 11888
phonon scattering in lutetium and yttrium, 17: 11221
plasma of, interactions and oscillations in, 17: 11867
polarization by magnetized iron foils, 17: 11577
radiation emission in synchrotrons, coherent, 17: 11770 (BNL-767 (p.100-5))
reactions with helium, polarization of radiation from, 17: 11409
reactions with hydrogen, excitation and polarization of Balmer-$\alpha$ radiation in, 17: 11366
reactions with hydrogen atoms, ionization in, 17: 11407
recombination with ions in noble gas discharge, 17: 11384
scattering by aluminum crystals, energy distributions in, 17: 11757
scattering by atomic hydrogen, nonadiabatic theory of, 17: 11389
scattering by atomic hydrogen at 11.0 to 54.4 ev, 17: 11390
scattering by helium, resonance in elastic, 17: 11408
scattering by nuclei, partial-wave analysis of inelastic, 17: 11710
scattering by potentials, infrared effects in amplitudes of, 17: 11548
scattering conduction by localized moments in metals, 17: 11367
scattering of, in the Coulomb field, Regge trajectory charge expansion in, 17: 11905 (JINR-E-1095)
selection rule for ($e$-$\mu$) symmetry, 17: 11478 (LNF-62/97)
spin-coupling in gadolinium metals, 17: 11417
**ELECTROSTATIC ANALYZERS**
design of pulsed, for ion beam analysis, 17: 11010 (TID-16311)
**ELECTROSTATIC GENERATORS**
design and performance for polarization studies, 17: 11815
ion acceleration by, measurements of, 17: 10928
**ELECTROSTATIC PRECIPITATORS**
design and performance of, for sampling fallout, 17: 10856 (NP-12351)
flowrate calibration, 17: 10902(R) (NYO-9676)
**ELEMENTARY PARTICLES**
biological effects of heavy cosmic ray, in man, 17: 10353 (BNL-6098)
biological effects of heavy cosmic radiation on mammalian skin, 17: 10363(R) (TID-17676)
classification based on massless Dirac field, 17: 11537
decay processes, 17: 11562
energy states of relativistic spin-½, Klein's paradox for, 17: 11580
interaction amplitudes for, resonant partial wave, 17: 11530
interaction with delta-function potential, 17: 11910
interactions of, coefficients of SU, group for, 17: 11928
interactions of, cross section and threshold anomalies in inelastic, 17: 11554
interactions of, higher symmetry schemes for electromagnetic and weak, 17: 11477 (LNF-62/94)
interactions of, isotopic spin independence in, 17: 11561
interactions of, many-body problems in, 17: 11481 (NP-12435(Pt.I))
interactions of, mathematics of many-body, 17: 11482 (NP-12435(Pt.II))
interactions of, method of estimating inhomogeneous events, 17: 11475 (JINR-P-1085)
interactions of, model of weak, 17: 11562
interactions of, phenomenological analysis of, 17: 11566
interactions of, Regge pole trajectory in elastic, 17: 11486 (NP-12479)
interactions of, representations of rotation groups in, 17: 11569
interactions of, strength of coupling constant in strong, 17: 11924
interactions of, vector theory of strong, 17: 11496 (TID-17742)
interactions, review of new resonances, 17: 11464 (AFOSR-2978)
localizability of quantum mechanical systems of, 17: 11929
poles of Green functions for, relation to excitation energies, 17: 11517
quantized field theory of, inversion of bare constants in, 17: 11520
quantized probability-amplitude field theory formulation for, 17: 11519
quantum theory of relativistic, with derived Hilbert-space, 17: 11579
reactions with nuclei in crystals, averages of primary recoil distributions in, 17: 11750
research in high-energy, 17: 11331(R) (TID-17023)
resonant states of, statistical background of, 17: 11474 (JINR-P-1079)
scattering amplitudes of, behavior of, 17: 11912
scattering at high energies, semi-classical picture for elastic, 17: 11925
scattering by fields, hypervirial theorem in, 17: 11908
scattering of, angular momentum poles of S matrix for, 17: 11913
scattering of, complex angular momentum in relativistic theory of, 17: 11521
scattering of, S matrix representations for, 17: 11914
scattering of, velocity-dependent nucleon–nucleon Green potential in, 17: 11527
scattering theory, hypervirial theorem of, 17: 11909
scattering trajectories for, two Pomeranchuk-Regge, 17: 11915
spin of, effects on Regge pole positions, 17: 11485 (NP-12478)
wave functions of particles with spin, solutions in spherical coordinates, 17: 11504
**EMBRYOS**
culture of organs, 17: 10407
protective effects of injected tissues, against radiation injury in mice, effects of embryo age, 17: 10421
radiation effects on development of lung cells, in tissue culture,

17: 10420
radioinduced sterilization of female and male chick, 17: 10375
**EMULSIONS**
creaming ratios and phase uniformity of oil-water, tracer study, 17: 10884
**ENGINEERING TEST REACTOR**
control rods in, worths of black and gray, 17: 12029
**ENZYMES**
radiation effects on activity in animal tissues by ion displacement, 17: 10469
radiation effects on, in rat liver, 17: 10478(R) (NP-12251(p.1-11))
radiation effects on, in rat liver, 17: 10479(R) (NP-12251(p.12-21))
radiation effects on fumarase activity in *Tetrahymena pyriformis GL* during cell division, 17: 10409
**EPITHELIUM**
radiosensitivity of intestinal, 17: 10355 (BNL-6113)
**EQUATION OF STATE**
of uranium in critical region, 17: 11183 (AWRE-0-61/62)
**ERBIUM**
reactions with ammonium nitrate and sulfate and potassium and sodium sulfates, precipitation, 17: 10621
**ERBIUM ALLOYS**
Er–Gd, electric conductivity, 17: 11190 (IS-477)
**ERBIUM CHLORIDES**
paramagnetic spin-lattice relaxation of hydrated, at 1.1 to 4.2°K, 17: 10652
**ERBIUM CRYSTALS**
electric conductivity of, effects of screw-spin ordering on, 17: 11413
**ERBIUM SELENIDES**
thermoelectric properties of sesqui-, 17: 11292 (AD-277043)
thermoelectric properties, 17: 11296 (AD-278352)
**ERYTHROCYTES**
binding of dyes by, 17: 10850(R) (HW-73337(p.77-157))
radioinduced hemolysis, effects of various chemical treatments, 17: 10850(R) (HW-73337(p.77-157))
**ERYTHROPOIESIS**
in leukemia patients, tracer study, 17: 10341
**ESCHERICHIA COLI**
Borek-Ryan effect in, mechanism of, 17: 10382
radiation effects, genetic, 17: 10364(R) (TID-17690)
radiation effects, protective effects of β-mercaptoethylamine and anoxia, 17: 10426
radiation injuries in, effects of dithiocarbamates against, 17: 10428
radiosensitivity of mutation, 17: 10364(R) (TID-17690)
**ETHANE**
luminescence and scintillation properties of 2,5-diaryl-oxazole derivatives of, in polystyrene, 17: 11227(T)
**ETHANE, BROMO-**
dissociation in G-M tubes, kinetics of, 17: 11025
**ETHANE, CHLORO-**
dissociation in G-M tubes, kinetics of, 17: 11025
effects on growth and survival of durum wheat, comparison with radiation effects, 17: 10388
**ETHANE, HEXABROMO-**
annealing of recoil bromine-82 in, effects of defects on, 17: 10673 (BNL-6535)
**ETHANE, IODO-**
dissociation in G-M tubes, kinetics of, 17: 11025
neutron reactions (n,γ) in, electric field separation of products from, 17: 10702
**ETHANETHIOL, 2-AMINO-**
protective effects against radiation injuries in *Escherichia coli*, 17: 10426
protective effects against lethal x-irradiation administered at various times after injection, 17: 10488
protective effects against radiation injury to cells in tissue culture, 17: 10491
protective effects on radioinduced chromosome aberrations in grasshoppers, effects of anoxia, 17: 10492
protective effects against radiation injury in cells in tissue culture, 17: 10493
**ETHANOL**
radiosensitivity effects on vitamin $B_{12}$, 17: 10718
**ETHERS**
radiation effects on aliphatic poly-, 17: 10678 (PAN-306/XVII)
**ETHYL SULFATES**
effects on growth and survival of durum wheat, comparison with radiation effects, 17: 10388
**ETHYLAMINE**
distillation of, with carbon dioxide, isotope effects in, 17: 10521
**ETHYLAMINE, 2,2'-DITHIOBIS-**
radiosensitivity effects on thymocytes, 17: 10487
**ETHYLAMINE, *N*-METHYL-**
distillation of, with carbon dioxide, isotope effects in, 17: 10521
**ETHYLENE**
luminescence and scintillation properties of 2,5-diaryl-oxazole derivatives of, in polystyrene, 17: 11227(T)
radiolysis products of, 17: 10509(R) (ORNL-3320(p.30-46))
**ETHYLENE, CHLORO- POLYMERS**
radiation effects on discoloration of, mechanism of, 17: 11281
**ETHYLENE GLYCOL**
heat transfer of, in axial and swirl flow, 17: 10808
**ETHYLENE, IODO-**
radioinduced polymerization of, properties and yield in, 17: 11284
**ETHYLENE POLYMERS**
beta sorption and glass transition in, effects of temperature on, 17: 11282
ethylene polymer-$U_3O_8$, fabrication of reactor fuel elements of, 17: 12027
moisture barrier properties of, effects of chlorination, fluorination, and grafting with halogenated monomers, 17: 10666(R) (RAI-303)
neutron attenuation and capture radiation in slabs of borated, 17: 11900 (NARF-62-16T)
radiation effects of alpha particles on chemical properties, 17: 10674 (BRL-1177)
radiation effects on internal motion of, nuclear magnetic resonance studies, 17: 10708
radiation effects on dielectric properties, gamma, 17: 11277
radiation effects on dielectric losses in, 17: 11278
radiation energy deposition in, reactor, 17: 11280
radioinduced crosslinking of, review on, 17: 10684
radioinduced crosslinking of, mechanism of, 17: 11279
radiolysis of, plastification in, 17: 10688
**ETHYLENE, TETRAFLUORO- POLYMERS**
positronium decay in, 17: 11627 (TID-15088)
radiation energy deposition in, reactor, 17: 11280
**EUROPEAN ATOMIC ENERGY COMMUNITY**
fast-reactor development by, 17: 11970
nuclear power economics and prospects in, 17: 10251
**EUROPIUM**
determination in rare earths, polarographic, 17: 10572
**EUROPIUM ISOTOPES Eu-145**
gamma spectra, 17: 11719
**EUROPIUM ISOTOPES Eu-146**
gamma spectra, 17: 11719
**EUROPIUM ISOTOPES Eu-147**
gamma spectra, 17: 11719
**EUROPIUM ISOTOPES Eu-151**
nuclear moments of, 17: 11702
quadrupole hyperfine structure in neodymium ethyl sulfate, 17: 11647 (UCRL-10202)
**EUROPIUM ISOTOPES Eu-152**
hyperfine structure of, 17: 11702
nuclear moments of, 17: 11702
quadrupole hyperfine structure in neodymium ethyl sulfate, 17: 11647 (UCRL-10202)
**EUROPIUM ISOTOPES Eu-153**
quadrupole hyperfine structure in neodymium ethyl sulfate, 17: 11647 (UCRL-10202)
**EUROPIUM ISOTOPES Eu-154**
quadrupole hyperfine structure in neodymium ethyl sulfate, 17: 11647 (UCRL-11647)
**EVAPORATORS**
design for waste processing, 17: 12053
**EXOSPHERE**
plasma density in, measurement of, 17: 11447

**EXPERIMENTAL BOILING WATER REACTOR**
development, 17: 11935(R) (ANL-6658)
operation, 17: 11936(R) (ANL-6672)
**EXPERIMENTAL BREEDER REACTOR**
criticality studies, 17: 11936(R) (ANL-6672)
development, 17: 11935(R) (ANL-6658)
**EXPERIMENTAL BREEDER REACTOR-II**
development, 17: 11935(R) (ANL-6658)
development, 17: 11936(R) (ANL-6672)
**EXPERIMENTAL GAS COOLED REACTOR**
control rod worth measurements, 17: 11958 (TID-11601)
coolant flow loss effects in, computer calculation of, 17: 11987 (ORNL-TM-476)
development and testing, 17: 11955(R) (ORNL-3372)
fuel assembly for, heat transfer and coolant pressure drop effects of, 17: 11989 (TID-11604)
refueling, design of charge machine for operational, 17: 12007
**EXPLODING WIRE PHENOMENA**
use as light source in optical interferometer, 17: 11853
**EXPONENTIAL PILES**
neutron flux distributions in, two-group theory of, 17: 11303(R) (HW-75228)
spectral and fine structure measurements in uranium–heavy water and uranium–water, 17: 11940 (CRRP-895)
**EXTRUSION**
techniques for, development of, 17: 11130
**EYES**
radiation effects on immunological reaction in postoperative corneal grafts, beta, 17: 10439

# F

**FALLOUT**
monitoring in Minnesota, 1959, 17: 10352
sampling of, design of electrostatic precipitator for, 17: 10856 (NP-12351)
studies of, in New Zealand, 17: 10243 (NP-12381)
**FAST NEUTRONS**
ages in cylindrical bore holes, 17: 10833
biological effects in mice, effects of linear energy transfer on early response, 17: 10358 (BNL-6575)
capture of, gamma emission in, 17: 11659
detection and measurements, design of argon-hydrogen ionization chamber for, 17: 11035
detection and measurement of, design of instrument for, 17: 10889 (AD-252467)
dosage determinations around and in human phantoms by nuclear emulsions, 17: 10868 (UCRL-9967(Rev.))
effects on growth and survival of durum wheat, comparison with effects of mutagenic agents, 17: 10388
production of vacancies in gamma-irradiated sodium chloride by, 17: 11377
scattering by calcium, elastic, 17: 11593 (PAN-354/I-A)
scattering by carbon-12, polarization in elastic, 17: 11741
scattering by square-mound-potential gas, 17: 11607
scattering by tantalum-181 and tungsten-184, cross sections for inelastic, 17: 11936(R) (ANL-6672)
scattering of, equipment for measuring, 17: 10240(R) (NP-12208)
**FAST REACTORS**
construction and principles of breeder, 17: 12021
description and development of, 17: 11970
**FECES**
analysis for tritium as vitamin A by liquid scintillation, 17: 10552
zinc distribution and turnover in, in rats, tracer study, 17: 10275
**FERMIONS**
BCS-reduced Hamiltonian for, linear response function of, 17: 11582
energy distributions in many-body systems, thermodynamic Green functions in quasi-particle approach for, 17: 11581
interactions of spin-½ with spin-0 bosons, 17: 11570
interactions with external fields, amplitudes for, 17: 11508
properties of, effects of Regge poles on, 17: 11466 (CERN-62-33)
reduced density matrices in coordinate space representation, 17: 11423
**FERMIUM**
radiography of, techniques for, 17: 10535 (JINR-P-1118)
**FERMIUM ISOTOPES Fm-252**
separation by solvent extraction, comparison of hydrochloric and nitric acid systems with TBP, 17: 10735 (JINR-P-1075)
**FERMIUM ISOTOPES Fm-254**
fission of, energy and mass distribution and half life of spontaneous, 17: 11649 (UCRL-10481)
**FERMIUM ISOTOPES Fm-255**
fission of, half life observations on, 17: 11649 (UCRL-10481)
**FERMIUM ISOTOPES Fm-256**
separation by solvent extraction, comparison of hydrochloric and nitric acid systems with TBP, 17: 10735 (JINR-P-1075)
**FERROMAGNETIC MATERIALS**
neutron scattering by lattice defects, 17: 11610
**FERTILIZERS**
protective effects of nitrogen, against radiation damage to grain and sugar beets, 17: 10442
**FETUSES**
plutonium-239 distribution in mouse, autoradiography of injected, 17: 10260
**FIELD THEORY**
annihilation of antibaryons on baryons, distributions from, 17: 11547
asymptotic properties of fields and space-times in, 17: 11401
baryon excited states in, unitary-symmetry model for, 17: 11557
conditions for relativistic, 17: 11926
distribution function of, in quantum-mechanical phase space, 17: 11927
elementary particle classification based on a massless Dirac field, 17: 11537
energy eigenvalues of many-body systems in, 17: 11357
energy spectra of isotopic impurities in lattices, 17: 11410
excitons in superconductors, impurity-scattering effects on, 17: 11412
higher symmetry schemes for electromagnetic and weak transitions in, 17: 11477 (LNF-62/94)
interactions of quantized fields in, mathematical basis of, 17: 11923
invariance under inversion of bare constants in quantized, 17: 11520
many-body problems in, 17: 11481 (NP-12435(Pt.I))
model of weak interactions, 17: 11562
phonon-phonon interactions in Bose systems, 17: 11411
quantization of the electromagnetic field, 17: 11911
quantized probability amplitudes in, physical effects of, 17: 11425
quantized probability-amplitude in, relativistically invariant formulation of, 17: 11519
Regge trajectory in, 17: 11919
relation of bispinor and spinor theory in Riemann space, 17: 11931
scattering amplitudes in, analytic properties of partial-wave, 17: 11572
spectral line widths in, calculation by Green's functions, 17: 11358
spin-0 and spin-1 bosons in, 17: 11509
strength of coupling constant in strong interactions, 17: 11924
transformations for spin-½-particle–field interactions in, 17: 11508
**FILTERS**
development of, for use in radiation-resistant pneumatic systems, 17: 10774(R) (GDC-63-001)
inspection of high-efficiency, development of di-octyl phthalate tester for, 17: 10922
**FINNED TUBES**
thermal efficiency of coated, 17: 10796 (IS-571)
**FISH**
radioactivity in Lake Maggiore, 17: 10349
**FISSION CHAMBERS**
design for neutron flux measurements at very high temperatures, 17: 10987
**FISSION PRODUCTS**
adsorption on minerals, 17: 10851(R) (HW-73337(p.158-237))
detection of spontaneous, techniques for, 17: 10535 (JINR-P-1118)
determination in graphite specimens from irradiated fuel elements, 17: 11934 (AERE-R-3453)
determination in TORY-IIA effluents, 17: 11953 (NARF-61-45R)
diffusion of gaseous, from minerals, 17: 10829
metabolism by laboratory and domestic animals, 17: 10310(R) (TID-17789)
processing by solvent extraction for cesium-137 separation, 17: 10757

release from gas-cooled fuel element, 17: 11944 (GAMD-3378)
separation from irradiated U–Zr fuel alloy, 17: 10742 (ORNL-TM-447)
separation from thorium and uranium by solvent extraction using butyl phenylphosphates and butyl phosphates, 17: 10738 (ORNL-3374)
separation of beryllium from, by coordination complexes, 17: 10498 (AAEC/TM-161)
shipping, release of strontium, cesium, and cerium isotopes by accidental firing of containers, 17: 10851(R) (HW-73337(p.158-237))
tracks of, in emulsions, 17: 11039
transport through soil, 17: 10820 (BNL-6554)
use as radiation sources, review on, 17: 10684

**FLOWMETERS**
design and performance of ion tracer air velocity meter for rarefied atmospheres, 17: 10902(R) (NYO-9676)

**FLUID FLOW**
analysis of flow systems, computer code for, 17: 10798 (KAPL-M-LXW-1)
book: *Physicochemical Hydrodynamics*, 17: 10813(T)
burnout in vertical annuli, 17: 10789 (AE-100)
flooding in gas-liquid countercurrent flow in vertical tube, effects of liquid viscosity, 17: 10788 (62GL132)
heat and mass transfer in, for smooth tubes at Reynolds numbers from $10^3$ to $10^5$, 17: 10790 (AERE-R-4197)
heat transfer in air-water, through parallel-rod arrays, 17: 10812
heat transfer in Couette, 17: 10802 (TID-17664)
heat transfer of ethylene glycol in axial and swirl, high flux, 17: 10808
in packed-sphere beds, 17: 11955(R) (ORNL-3372)
magneto-fluid-dynamic, distributions in, 17: 11352
magnetohydrodynamics of viscous, conducting, axially-symmetric, 17: 11438
mixing in flow parallel to rod bundle, 17: 10804 (WCAP-1607)
pressure drop in two-phase flow in channels, 17: 10792(R) (GEAP-4148)
stability in thin-walled channels, 17: 11966(T,R) (EURAEC-465)
stability of axially-symmetric, in magnetic field, 17: 11439

**FLUID FLOW (LAMINAR)**
heat transfer in monatomic gases during, at plasma temperatures, 17: 11842

**FLUID FLOW (TURBULENT)**
bubble motion in, research program, 17: 10803(R) (TID-17719)

**FLUID FUEL REACTORS**
design description of Jülich pebble-bed, 17: 11998(T) (AEC-tr-5484)

**FLUID PROPELLANTS**
development of heavy-ion-type, for electrical propulsion systems, 17: 11302 (ASD-TR-61-150(Pt.II))

**FLUIDIZATION**
disturbances in, effects of electrostatic phenomena on, 17: 11202(T) (AEC-tr-5621)
use of fluidized beds in reprocessing solid reactor fuels, 17: 10730 (BNL-6195)

**FLUOBORIC ACID**
Cr–$HBF_4$–HF–$HNO_3$–Zr, solvent properties for uranium–zirconium alloy, 17: 10246(R) (ORNL-TM-403)

**FLUORIDE VOLATILITY PROCESSES**
development, 17: 10744 (TID-13765)
development for recovery of uranium from unirradiated fuel elements, 17: 10728 (BNL-6148)

**FLUORINE**
bonding with carbon in organic compounds, nuclear magnetic resonance spectra of, 17: 11356
determination by nuclear magnetic resonance, 17: 10946
determination in concentration products using polonium-210, activation, 17: 10570

**FLUORINE ISOTOPES F-19**
deuteron reactions (d,n) at 1.0 and 1.3 Mev, angular distributions of neutrons from, 17: 11636(R) (TID-17720(p.8-14))
deuteron reactions (d,$He^3$) at 21.6 Mev, angular distributions, 17: 11299(R) (ANL-6612)
energy level transitions in, 17: 11660
neutron reactions (n,γ), cross sections of thermal, 17: 11694

**FLUORINE ISOTOPES F-20**
half-life and decay modes of, 17: 11694

**FLUOROAROMATIC COMPOUNDS**
radiation chemistry of Genetron in aqueous solutions, 17: 10850(R) (HW-73337(p.77-157))

**FLUOROHALOCARBON POLYMERS**
radiation effects on dielectric losses in, 17: 11278

**FLUOROÖRGANIC COMPOUNDS**
spectra of, bonding between carbon and fluorine in nuclear magnetic resonance, 17: 11356

**FOOD**
monitoring for radioactive contamination, 17: 10310(R) (TID-17789)
movement in small intestine in rats, tracer study using yttrium-91, 17: 10281
radiation effects on *Clostridium botulinum* spores in meat, effects of low temperatures on, 17: 10883
radiation monitoring in France during September 1962, 17: 10864 (SCPRI(RM)62-9)
radiation monitoring in France during October 1962, 17: 10865 (SCPRI (RM)62-10)
technological developments, applications of radioisotopes in, industry and research on, 17: 10882

**FORESTS**
radiation effects on reproductive potentialities of pine-oak, 17: 10362 (TID-16254)

**FORMALDEHYDE**
radiation effects on electron paramagnetic resonance spectra of, 17: 10695
yields in radiolysis of liquid methanol, effects of salt solutions on, 17: 10699

**FORMIC ACID**
decomposition of, uranyl sensitized photo-, 17: 10697
metabolism by irradiated bacteria, 17: 10468

**FRANCE**
radiation monitoring in, Sept. 1962, 17: 10864 (SCPRI(RM)62-9)
radiation monitoring in, Oct. 1962, 17: 10865 (SCPRI(RM)62-10)

**FREE RADICALS**
radioinduced formation in hydrogen peroxide, 17: 10679 (TID-15898)

**FREQUENCY ANALYZERS**
phase discriminator for tuning cavity resonators, 17: 11791 (RT/EL(62)14)
phase-locked oscillator analog for particle motion studies, 17: 11774 (BNL-767(p.161-71))

**FUEL CELLS**
bibliography, 17: 11322 (NP-12429)

**FUNGI**
radiation effects on genetics of *Neurospora crassa* exposed to nitrogen mustard, visible, 17: 10455
radiation effects on, on wheat, 17: 10374
radiation effects on catalase accumulation in conidia of *Aspergillus niger*, ultraviolet and x ray, 17: 10397

**FUSED SALTS**
research programs on electrochemistry and thermochemistry of, 17: 10518(R) (TID-17823)

# G

**GADOLINIUM**
determination using diammonium-5,5′-indigo disulphonate, 17: 10568
g-shift in, 17: 11417
Hall effect in, anomalous, 17: 11417
neutron effective cutoff energies, 17: 10506(R) (ORNL-3320(p.1-15))

**GADOLINIUM ALLOYS**
Er–Gd, electric conductivity, 17: 11190 (IS-477)
Gd–La, phase studies, 17: 11186 (DRI-2080)
Gd–La, superconductivity of foils of, 17: 11251
Gd–Lu, electric conductivity, 17: 11190 (IS-477)

**GADOLINIUM ARSENIDES**
thermoelectric properties, 17: 11296 (AD-278352)

**GADOLINIUM CHLORIDES**
paramagnetic spin-lattice relaxation of hydrated, at 1.1 to 4.2°K, 17: 10652

**GADOLINIUM HYDRIDES**
electronic structure, 17: 11329 (TID-15934)
magnetic properties, 17: 11329 (TID-15934)

**GADOLINIUM ISOTOPES Gd-146**

gamma spectra, 17: 11719
**GADOLINIUM ISOTOPES Gd-147**
gamma spectra, 17: 11719
**GADOLINIUM ISOTOPES Gd-152**
gamma decay, angular distribution coefficients, 17: 11647 (UCRL-10202)
**GADOLINIUM ISOTOPES Gd-154**
energy levels of, perturbation corrections to, 17: 11665
gamma decay, angular distribution coefficients, 17: 11647 (UCRL-10202)
**GADOLINIUM SELENIDES**
thermoelectric properties of sesqui-, 17: 11292 (AD-277043)
**GADOLINIUM SULFIDES**
thermoelectric properties of sesqui-, 17: 11292 (AD-277043)
**GADOLINIUM TELLURIDES**
thermoelectric properties of sesqui-, 17: 11292 (AD-277043)
thermoelectric properties, 17: 11296 (AD-278352)
**GADOLINIUM VANADATES**
structure of, x ray diffraction analysis of, 17: 10663
**GAGES**
design of phantom, for tolerancing of parts, 17: 10913 (TID-17740)
**GALLIUM**
determination in pure phosphorus, activation, 17: 10562
nuclear quadrupole resonance, 17: 10592 (IS-520)
**GALLIUM ARSENIDES**
radiation effects, 17: 11263 (NP-12361)
**GALLIUM CHLORIDES**
chemistry in basic solutions, 17: 10589 (IS-481)
**GALLIUM ISOTOPES Ga-66**
positron spectrum of, shape of $0^+ \rightarrow 0^+$, 17: 11724
**GALVANOMETERS**
design using semiconductors, 17: 10958
**GAMMA RADIATION**
absorption and emission in crystals, phonon effects on, 17: 11658
attenuation by lead, calculation of, 17: 11904
backscattering from plane concrete walls, 17: 11895 (AE-92)
backscattering from spherical concrete walls, 17: 11896 (AE-93)
biological effects on chickens, comparison with x rays, 17: 10471
biological effects in mice, effects of linear energy transfer on early response, 17: 10358 (BNL-6575)
carcinogenic effects in mice lungs, 17: 10476
detection and measurement of low-level, from internally deposited radioisotopes, 17: 10344
detection and measurement, design of pressure ionization chamber for, 17: 11015
detection in drill holes, probe design for, 17: 10836
effects on bone marrow in rats, whole-body, 17: 10413
effects on *Clostridium botulinum* spores in meat, effects of low temperatures on, 17: 10883
effects on corpuscles and proteic pattern of lymph of thoracic duct, 17: 10462
effects on development of embryonic lung cells in tissue culture, 17: 10420
effects on DNA and RNA in neurons of cerebellum and Gasser ganglion of rats, 17: 10466
effects on embryo-endo sperm ratios in seeds, 17: 10386
effects on growth and sexual development in cattle exposed *in utero*, 17: 10422
effects on hematopoietic system in rats, effects of spleen extract injections on, 17: 10369
effects on hematopoietic system in guinea pigs, effects of spleen extract injections on, 17: 10370
effects on intestinal epithelium, whole-body chronic exposure, 17: 10355 (BNL-6113)
effects on mouse testis, chronic exposure, 17: 10361 (TID-15852)
effects on non-disjunction of chromosomes in *D. melanogaster* combined with maternal age, 17: 10400
effects on reproductive potentialities of pine-oak forest, chronic, low-level exposure, 17: 10362 (TID-16254)
effects on tissue cultures of cervical and ovarian cancer cells, 17: 10261
effects on vitamin $B_{12}$, 17: 10718
emission by lattice-bound iron-57, temperature dependence of, 17: 11230
emission by quadrupole vibration states in spherical nuclei, 17: 11685
emission from chromium-51 and iron-59 in man, method for measurement of, 17: 10271
emission from fast neutron capture reactions, 17: 11659
intensity of betatron, effects of injector focusing on, 17: 11816
interactions with protons to 550 Mev, cross sections for, 17: 11564
interactions with protons, meson ($\pi^0$) production amplitude, 17: 11565
interactions with protons, differential cross section for, 17: 11574
leukemogenic effects in mice, whole-body exposure, 17: 10354 (BNL-6105)
measurements in extended homogeneous media, 17: 11040
physiopathological effects on brain in rats, 17: 10459
production of monochromatic, device for, 17: 11555
reactions (γ,α) with vanadium-51, spectra from, 17: 11678
reactions (γ,n) with phosphorus-31, cross sections for, 17: 11653
reactions (γ,n) and (γ,np) on nuclei, cross section for, 17: 11672
reactions (γ,n) with carbon-12 and oxygen-16 at 30.5 Mev, neutron spectra from, 17: 11755
reactions (γ,n) with nitrogen-14 and oxygen-18 at 30.5 Mev, neutron spectra from, 17: 11756
reactions on lithium isotopes, beta activity from, 17: 11728
reactions on nuclei, tensor effects on nucleon production in, 17: 11733
reactions with non-fissile materials, production of thermal energy in, 17: 11619 (CEA-2172)
scattering by concrete, formulas for differential dose albedo in, 17: 11901 (NP-12455)
scattering by iron, lead, silver, tantalum, and uranium at 7 and 17 Mev, 17: 11745
scattering in spherical concrete wall room, multiple, 17: 11897 (AE-94)
transport of, spherical harmonics technique for evaluating, 17: 11502 (WAPD-T-1458)
velocity of, from moving source, 17: 11331(R) (TID-17023)
**GAMMA SOURCES**
fabrication of cobalt-60, 17: 11176
handling of, for materials radiography, 17: 10818
simulation of point, electromagnetic, 17: 11503
use in scan system for inspection of tungsten billets, 17: 10816 (USNRDL-TR-602)
**GAMMA SPECTRA**
analysis of, fitting technique for, 17: 11444
**GAMMA SPECTROMETERS**
amplifier for, design of nonoverloading pulse, 17: 11032
design, calibration, and use of fast delayed coincidence, 17: 11627 (TID-15088)
performance of submerged, 17: 11040
properties of Compton, 17: 10240(R) (NP-12208)
**GAMMA SPECTROSCOPY**
developments, 17: 10850(R) (HW-73337(p.77-157))
**GAS CENTRIFUGES**
countercurrent flow in semi-infinite, 17: 11054 (UVA-279-63U)
countercurrent flow in semi-infinite, mixed thermal boundary condition for, 17: 11055 (UVA-280-63U)
**GAS COOLED REACTOR EXPERIMENT**
operation, spectral analysis, 17: 11978 (AGN-TM-399)
**GAS COOLED REACTOR EXPERIMENT-III**
design, 17: 11955(R) (ORNL-3372)
**GAS COOLED REACTORS**
control equipment and instrumentation development, 17: 10994
control system theory and design, 17: 10983
corrosion and transport of carbon in high-temperature, 17: 11981 (GA-2630)
design description of Jülich pebble-bed, 17: 11998(T) (AEC-tr-5484)
design of advanced power, 17: 11955(R) (ORNL-3372)
economics of heavy water moderated, natural uranium, 17: 12001
flow and temperature field determination in pebble-bed, 17: 11974
fuel performance analysis for graphite-moderated, 17: 11999(T) (AEC-tr-5610)
heat transfer in, 17: 11969
instrumentation for, operational view of, 17: 10995
moderator distortion in, graphite, 17: 11184 (BNL-758)
stability and control theory, 17: 10984
steam generators for, economic considerations in, 17: 12000
**GAS FLOW**
in circular tubes at 20 to 300°C, 17: 10811

**GAS TURBINE ENGINES**
development, 17: 12036(R) (SY-5396-R3)
**GASEOUS DIFFUSION PROCESS**
development of, in Sweden, review of, 17: 11060
use for separating tungsten isotopes, feasibility, 17: 11052 (TID-15348)
**GASES**
analysis of, procedure for mass spectrographic, 17: 10537 (TID-15724)
cleaning of, equipment and methods for, 17: 10846 (HW-61840)
dielectric constant of degenerate electron, 17: 11861
electron energy distributions in slightly ionized, 17: 11839 (UCRL-10366)
Gibbs statistics of isotope systems of ideal and real, in thermodynamic equilibrium, 17: 10655
heat and momentum transfer of monatomic, in laminar flow at plasma temperatures, 17: 11842
interactions of atoms and ions in, scattering and charge exchange cross sections for, 17: 11340(T) (AEC-tr-5615)
scattering in, structure of three-particle operator for, 17: 11513
separation by gas chromatography, design and performance of apparatus for, 17: 10955
sorption by metal films in vacuum, research program, 17: 11193(R) (TID-17635)
**GEIGER-MUELLER TUBES**
design for gamma logging in drill holes, 17: 10836
ethyl halide dissociation in self-quenching, kinetics of, 17: 11025
function of rods in, compartment theory for theory of, mathematical representation of compartment, 17: 11028
replacement of anodes in gas flow-type, 17: 11013 (UCRL-6845)
use in leak detector for x-ray tubes, 17: 11018
use of halogen-filled, in dose output measurements, 17: 10961
**GELATIN**
radiation effects on, in exposed nuclear emulsion, 17: 10703
**GENETICS**
effects of natural and radioinduced lethals in Drosophila population, 17: 10256(R) (TID-17699)
radiation effects on, in agriculture, studies in United Arab Republic on, 17: 10416
relation of mongolism to maternal irradiation, 17: 10436
relation to radiation effects on barley, 17: 10453
**GEOLOGY**
age estimation in, using radioisotopes, 17: 10832
book: *Problems in Radiogeology*, 17: 10841
book: *Theory of Similarity and Bore Hole Radiometry*, 17: 10842
radioisotopes in, USSR, 17: 10888
surface effects of underground nuclear explosions, development of instruments for studying, 17: 10819(R) (AD-278217)
**GEOMAGNETIC FIELDS**
disturbances in, cosmic ray effects of, 17: 11455
interactions with solar corpuscular radiation, investigation of, 17: 11449 (ML-975)
**GEOMAGNETIC STORMS**
effects on F-layer critical frequencies and outer Van Allen belt intensities, 17: 11453
**GEOPHYSICAL PROSPECTING**
book: *Theory of Similarity and Bore Hole Radiometry*, 17: 10842
**GEOPHYSICS**
radioisotopes and nuclear reactions in, 17: 10841
**GERMANIUM**
determination in quartz, activation, 17: 10574
**GERMANIUM CRYSTALS**
solvent properties for cobalt, 17: 10240(R) (NP-12208)
**GERMANIUM FILMS**
preparation of thin, 17: 11178
**GERMANIUM IODIDES**
thermal decomposition of, preparation of thin metal films by, 17: 11178
**GERMANIUM ISOTOPES Ge-71**
energy levels, 17: 10506(R) (ORNL-3320(p.1-15))
**GERMANIUM ISOTOPES Ge-73**
energy levels, 17: 10506(R) (ORNL-3320(p.1-15))
**GERMANIUM ISOTOPES Ge-75**
energy levels, 17: 10506(R) (ORNL-3320(p.1-15))
**GERMANIUM ISOTOPES Ge-77**
energy levels, 17: 10506(R) (ORNL-3320(p.1-15))
**GLASS**
development of cerium-activated, for alpha counting, 17: 11003 (HW-72512)
diffusion of cesium and strontium in, activation energy and coefficients of, 17: 10642
leaching of boron from raschig rings by thorium–uranium solutions, 17: 10246(R) (ORNL-TM-403)
properties of fuel-bearing, 17: 11102(R) (NYO-9735)
sorptive properties of Vycor, for protactinium, 17: 10246(R) (ORNL-TM-403)
stress-rupture analysis, 17: 11937(R) (ARF-4132-16)
**GLOW DISCHARGES**
radiation emission by electrons in, 17: 11829 (ASD-TR-61-179(Vol.I))
**GLUCOSE**
metabolism by irradiated bacteria, 17: 10468
**GLUTARIC ACID**
decomposition of, uranyl sensitized photo-, 17: 10697
**GLYCEROL**
protective effects against radiation injury in cells in tissue culture, 17: 10493
**GLYCOLS**
production by photoreduction of benzophenone, effects of retarders on, 17: 10680(R) (TID-17584)
protective effects against radiation injury, 17: 10480(R) (NP-12251 (p.22-33))
solvent properties for inorganic ions, 17: 10749 (TID-17746)
yields in radiolysis of liquid methanol, effects of salt solutions on, 17: 10699
**GOLD**
determination in silicate rock, activation, 17: 10573
deuteron scattering at 3 to 30 Mev, optical model analysis of, 17: 11676
neutron capture by, gamma emission in fast, 17: 11659
proton reactions at 2.9 Bev, nuclear charge distributions in, 17: 11727
radiation effects, 17: 11129
separation from metal ionic mixtures, electrochromatographic, 17: 10753
sorptive properties for promethium-147, surface, 17: 11244
sputtering by krypton at 400 to 1000 ev, energy of atoms in, 17: 11374
**GOLD ALLOYS**
Cu–Au, conduction electron momentum in, electron–positron annihilation studies, 17: 11275
Cu–Au–Ag, restoration in deformed, 17: 10240(R) (NP-12208)
**GOLD CHLORIDES**
radioreduction in aqueous solution, effects of pH and excess chloride on, 17: 10696
**GOLD ELECTRODES**
testing in potassium chlorate and chloride, capacity–potential behavior of, 17: 11135(T,R) (EURAEC-483)
**GOLD FOILS**
neutron self-shielding coefficients for, 17: 11609
**GONADS**
effects of irradiation of testes, on weight of offspring, in swine, 17: 10414
radiation effects, chronic gamma exposure, 17: 10361 (TID-15852)
radiation protection of, by apron, 17: 10873
radiosensitivity of, in cattle exposed *in utero*, 17: 10422
zinc distribution and turnover in, in rats, tracer study, 17: 10275
**GRAIN-BOUNDARY DIFFUSION**
in polycrystalline materials, method for separation of, 17: 11236
**GRAIN GROWTH**
in sintering, review of, 17: 11090 (HW-SA-460)
**GRANITE DEPOSITS (ITALY)**
beryllium content of Mount Capanne and Island of Giglio, 17: 10827
**GRAPHITE**
development of pyrolytic, for use in solid-propellant rocket motors, 17: 11076 (AD-278371)
electric properties in magnetic fields, radiation effects, 17: 11103 (TID-16243)
neutron resonance absorption in, grain effects on, 17: 11604
permeability of, effects of helium stream in-sweeping on, 17: 11189 (GAMD-2638)
properties in air-cooled reactors, 17: 11184 (BNL-758)

properties of, for use as reactor moderator, technical progress review, 17: 11127
radiation damage in, activation energy for annealing neutron, 17: 11255 (BNL-6083)
radiation effects on electric properties, 17: 11103 (TID-16243)
sampling of cylindrical specimens of, from fuel elements, design of equipment for, 17: 11934 (AERE-R-3453)
spectral emissivity of pyrolytic, at high temperatures, 17: 11191(R) (NP-12483)
stored energy in irradiated, design of calorimeter to measure, 17: 10974

**GRAPHITE (IMPREGNATED)**
radiation effects at 1500°C to 10% burnup, 17: 11261 (LAMS-2814)

**GRAPHITE COATINGS**
deposition on molybdenum and uranium carbides, 17: 11174

**GRAPHITE ELECTRODES**
chemical effects on carrier distillation excitation of impurities in uranium(IV-VI) oxide, 17: 10538 (TID-16295)

**GRAPHITE MODERATED REACTORS**
corrosion and transport of carbon in high-temperature gas-cooled, 17: 11981 (GA-2630)
fuel performance analysis for gas-cooled, 17: 11999(T) (AEC-tr-5610)
moderator stability in air-cooled, 17: 11184 (BNL-758)

**GRAPHITE SYSTEMS**
$B_4C$–graphite, preparation, radiation effects, and stability under reactor conditions, 17: 11085 (GA-3064)

**GRASS**
radioactive contamination of Minnesota, 1959, 17: 10352

**GRASSHOPPERS**
radioinduced chromosome aberrations, effects of cysteamine treatment and anoxia, 17: 10492

**GRAVITATION**
asymptotic properties of fields of, in relativity theory, 17: 11401
space-time in Hund theory of, 17: 11351
variance of Planck's constant in field of, application to theory of red shift of, 17: 11305 (IFT-1)

**GROUND WATERS**
decontamination, ion exchange, 17: 10820 (BNL-6554)
flow velocities of, tracer techniques for measuring, 17: 10885
flow velocities of, tracer technique for measuring relative, 17: 10886
monitoring in Hanford Area, 17: 10822 (HW-SA-2566)

**GUINEA PIGS**
radiation and encephalomyelitis virus effects on bone marrow and lymph system in, 17: 10427
radiation effects on cells of, 17: 10383
radiation injuries in hematopoietic system in, effects of spleen extract injections on, 17: 10369
radiation injuries in hematopoietic system in, effects of spleen extract injection on, 17: 10370
radiation sickness of, effects of, on maturation and proliferation of bone marrow in, 17: 10495

# H

**HAFNIUM**
determination i. aluminum as trace impurity, activation, 17: 10546
preparation of thin foils of, 17: 11178

**HAFNIUM ALLOYS**
Hf–Mo, hardness, 17: 11094(R) (NMI-2113)
Hf–Nb, properties of welded, 17: 11242
Hf–Tc, phase studies on, 17: 11220

**HAFNIUM BORIDES**
bibliography on preparation and properties of, 17: 10579 (ASD-TDR-62-873)
thermoelectric properties at 2100 to 2200°K, 17: 11436

**HAFNIUM CARBIDES**
melting point, 17: 11201(T) (AEC-tr-5598)
physical properties, 17: 11215
thermoelectric properties at 1300 to 2160°K, 17: 11436
HfC–TaC, melting point, 17: 11201(T) (AEC-tr-5598)

**HAFNIUM FLUORIDE COMPLEXES**
properties of, computer analysis of potentiometric and solvent extraction studies of, 17: 10600 (TID-15939)

**HAFNIUM IODIDES**
thermal decomposition of, preparation of thin metal films by, 17: 11178

**HAFNIUM ISOTOPES Hf-176**
neutron capture cross sections and resonances for, 17: 11805(R) (TID-17728)

**HAFNIUM ISOTOPES Hf-177**
neutron capture cross sections and resonances for, 17: 11805(R) (TID-17728)
neutron reactions (n,γ), gamma spectrum from, 17: 11711

**HAFNIUM ISOTOPES Hf-178**
energy levels, 17: 11711
neutron capture cross sections and resonances for, 17: 11805(R) (TID-17728)

**HAFNIUM ISOTOPES Hf-179**
neutron capture cross sections and resonances for, 17: 11805(R) (TID-17728)

**HAFNIUM ISOTOPES Hf-180**
deuteron pickup by, angular momentum in, 17: 11662
neutron capture cross sections and resonances for, 17: 11805(R) (TID-17728)

**HAFNIUM NITRIDES**
vaporization at 2031 and 2238°K, mechanism of, 17: 11197(R) (NP-12483)

**HAFNIUM OXIDES**
thermoelectric properties at 2100 to 2500°K, 17: 11436

**HAIR**
radioinduced greying, reaction mechanisms, 17: 10363(R) (TID-17676)

**HALLAM POWER REACTOR**
design and construction, review, 17: 12003

**HANDBOOKS AND MANUALS**
on reactors built, being built, and planned in United States, 17: 11957 (TID-8200(7th Rev.))

**HANDS**
radioactive contamination of, monitor for, 17: 10962

**HANFORD AREA (WASH.)**
geology and ground water flow, 17: 10851(R) (HW-73337(p.158-237))

**HANFORD PRODUCTION REACTORS**
air leakage into gas atmosphere of, determination by measurements of radioactive argon, 17: 11948 (HW-SA-2584)
coolant decontamination, 17: 12041 (HW-SA-2192)
development of data logging systems for, 17: 11946 (HW-SA-2549)

**HASTELLOY X**
brazing and welding of, criteria for, 17: 11163 (DMIC-181)
radiation effects on tensile properties, 17: 11087(R) (GEMP-19A)
radiation effects on mechanical properties, 17: 11129

**HAYNES 25 ALLOY**
corrosion by carbon tetrachloride–chlorine/oxygen, 17: 10246(R) (ORNL-TM-403)

**HEALTH PHYSICS**
bio-assay and analytical chemistry procedures, 17: 10522 (ANL-6637)
book: *On Practical Problems in Ionizing Radiation Dosimetry*, 17: 10879
instrumentation developments in, survey of, 17: 10960
mobile laboratory design, 17: 10877
procedures for handling serious radiation accidents, 17: 10855 (HW-SA-2609)
research activities at Hanford works, 1961, 17: 10847(R) (HW-73337)
statistical evaluation of data, 17: 10869 (Y-KB-7)

**HEART DISEASES**
diagnosis of associated renal disease by renal excretion of mercury-203 labeled mercaptomerin sodium, 17: 10345

**HEAT-RESISTING ALLOYS**
crack propagation resistance of high-strength, 17: 11075(R) (AD-278043)

**HEAT TRANSFER**
analysis of, computer programs for, 17: 10606 (UCRL-7069)
between tube wall and fluid streams at Reynolds numbers from $10^4$ to $10^6$, 17: 10790 (AERE-R-4197)
burnout in water-cooled high-pressure tubes, equations for, 17: 10806(T) (AEC-tr-5602)
conduction calculations, computer program for preparing code input data, 17: 10799 (LAMS-2809)
critical boiling water burnout, 17: 10807(T,R) (EURAEC-449)
from boiling potassium, development of loop for study of, 17: 10791

(BNL-6142)
from boiling potassium, design of facility for measurement of, 17: 12036(R) (SY-5396-R3)
from internally heated rods to flowing liquids, 17: 10810
from steam-heated copper tubes to isopropanol, effects of tube surface voltage on, 17: 10801(R) (NYO-10345)
in alkali metals under boiling and condensing conditions, 17: 11098(R) (NP-12433)
in Couette flow of radiating fluids with viscous dissipation, 17: 10802 (TID-17664)
in flow of air through circular tubes at 20 to 300°C, 17: 10811
in fuel elements of gas- or liquid-cooled reactors, computer program for analysis of, 17: 10795 (IDO-28595)
in monatomic gases during laminar flow at plasma temperatures, 17: 11842
in packed-sphere beds, 17: 11955(R) (ORNL-3372)
in PRTR fuel elements being cooled by transverse air flow, 17: 10793 (HW-72097(Rev.))
in uniformly heated tubes above and below critical heat flux, 17: 11941(R) (EURAEC-475)
mechanism in vapor-liquid mixtures, 17: 11965 (UNC-5008-I)
of ethylene glycol in axial and swirl flow, high-flux, 17: 10808
review, in nuclear engineering, 17: 12012
to air-water systems flowing through parallel-rod arrays, 17: 10812

**HEAVY WATER REACTORS**
design optimization of power, 17: 11979(R) (DP-805)
economics of gas-cooled, natural uranium, 17: 12001
heavy water losses, review, 17: 12016

**HELIUM**
diffusion from minerals, determination of activation energy spectra in, 17: 10830
electric discharge in, 17: 11836 (RADC-TDR-62-186)
electron collisions with, polarization of optical radiation induced by, 17: 11396
electron elastic scattering by, resonance in, 17: 11408
electron impact radiation from, polarization of, 17: 11409
energy levels of, 20-parameter eigenfunctions and energies of $2^1S$ states of, 17: 11751
excitation by hydrogen ions, 17: 10240(R) (NP-12208)
heat and momentum transfer of, in laminar flow at plasma temperatures, 17: 11842
interactions of ionized and neutral, with metal surfaces, secondary electron emission by, 17: 11397
oscillations in rotating liquid, torsional, 17: 11402
plasma decay characteristics of, 17: 11880
plasma diffusion characteristics of, 17: 11881
plasma diffusion decay in magnetic field, 17: 11890
purification system for, 17: 10772 (ANL-6652
reactions with hot tungsten surface at 1710 to 2500°K, energy exchange in, 17: 10609 (UCRL-10504)
reduced density matrices in coordinate space representation, 17: 11423
sound attenuation in liquid II, 17: 11414
ultrasonic attenuation in liquid II, 17: 11415

**HELIUM ION BEAMS (He-3)**
reactions with boron-11 and nitrogen-14, 17: 11721

**HELIUM IONS**
injection into vacuum magnetic field, light emission during, 17: 11854
mobility near lambda point in helium-4 liquid, measurement of, 17: 11312 (LNF-62/106)

**HELIUM ISOTOPES**
separation by thermal diffusion, 17: 10240(R) (NP-12208)

**HELIUM ISOTOPES He-3**
lattice defects in solid, 17: 11382
polarization of gaseous, 17: 11730
production by deuteron interactions with deuterons, 17: 11467 (IFF-4)
self-diffusion in solid, 17: 11382
specific heat of solid, anomalous, 17: 11382
thermodynamic properties at 0.02 to 0.3°K and pressures greater than minimum in pressure curve, 17: 10603 (TID-17721)

**HELIUM ISOTOPES He-4**
elementary excitations in liquid, energy spectrum of, 17: 11422
ion mobility near lambda point in, measurements of, 17: 11312 (LNF-62/106)

**HELIUM SYSTEMS**
He–H, electric discharge in, 17: 10240(R) (NP-12208)
He–Xe, characteristics of electric discharge in, 17: 11431

**HEMATOPOIETIC SYSTEM**
radiation injuries in guinea pig, effects of spleen extract injections on, 17: 10370
radiosensitivity of, in adult and newborn rats, 17: 10368

**HEMORRHAGE**
effects on DNA synthesis in peripheral blood cells in rabbits, 17: 10291

**HEXANE**
1-butanol–hexane, theory of ionic dissociation of lithium iodide in, 17: 10656

**HIGH-ALTITUDE EXPLOSIONS**
effects of thermonuclear, on resonance of earth-ionosphere cavity, 17: 10828

**HIGH ENERGY INJECTION DEVICES**
development, 17: 11831(R) (LAMS-2816)
development of IBIC, 17: 11840(T) (AEC-tr-5612)
performance curves for DCX-2, 17: 11835 (ORNL-3387)

**HIGH TEMPERATURE GAS COOLED REACTOR EXPERIMENT**
design description of Dragon, 17: 12019
materials evaluation, irradiation program for, 17: 12005

**HIGH TEMPERATURE SEPARATION PROCESSES**
development, 17: 11935(R) (ANL-6658)

**HOLMIUM**
determination in aluminum as trace impurity, activation, 17: 10546

**HOLMIUM HYDRIDES**
magnetic susceptibility and atomic moments, 17: 10599 (TID-15935)

**HOLMIUM ISOTOPES Ho-165**
deuteron reactions (d,p) on, holmium-166 energy levels from, 17: 11729

**HOLMIUM ISOTOPES Ho-166**
energy levels below 818 kev, rotational bands in, 17: 11729

**HOMOGENEOUS REACTORS**
radiolytic gas production in, analysis of conditions for, 17: 11952 (NAA-SR-7086)

**HYDRACRYLIC ACID, β-LACTONE**
effects on growth and survival of durum wheat, comparison with radiation effects, 17: 10388

**HYDRIDES**
properties of solid, for use as reactor moderator, technical progress review, 17: 11127

**HYDROCARBONS**
radiolysis of, physico-chemical problems in, 17: 10722

**HYDROCHLORIC ACID**
corrosive effects on pure stainless steel, 17: 11115(T,R) (EURAEC-482)

**HYDROCYANIC ACID**
radiation effects on synthesis from ammonia and methane, 17: 10704

**HYDRODYNAMICS**
book: *Physicochemical Hydrodynamics*, 17: 10813(T)
calculations in, use of particle-and-force models for, 17: 11310 (LA-2806)
equations of, application of finite difference schemes to, 17: 11323 (NYO-9188)
flows with shock, computations of, 17: 11324 (NYO-9603)

**HYDROFLUORIC ACID**
Cs–$HBF_4$–HF–$HNO_3$–Zr, solvent properties for uranium–zirconium alloy, 17: 10246(R) (ORNL-TM-403)
HF–$HNO_3$, corrosive effects on stainless steel, 17: 10246(R) (ORNL-TM-403)

**HYDROGEN**
collisions of, with electrons, effects of exchange and strong bond on cross sections for, 17: 11361(T)
composition of condensed molecular beam of, 17: 11428
determination in heavy water-water systems, 17: 10240(R) (NP-12208)
determination in liquids and solids by nuclear magnetic resonance, 17: 10946
effects of atomic, in diluted aqueous solutions, comparison with x-ray effects, 17: 10717
electron energy distributions and ionization rates in, effects of crossed electric and strong magnetic fields, 17: 11839 (UCRL-10366)

electron-ion drift velocities in, 17: 11430
electron reactions with, excitation and polarization of Balmer-α radiation, 17: 11366
electron scattering by atomic, nonadiabatic theory of, 17: 11389
electron scattering by atomic, at 11.0 to 54.4 ev, 17: 11390
equilibrium solubility in palladium–platinum alloys, 17: 10632
exchange with deuterium in phenyl- and *p*-tolyl 2-octyl-2-d-sulfones, base catalyzed, 17: 10670
excitation of, in collisions in plasma, 17: 11407
interactions of ionized and neutral, with metal surfaces, secondary electron emission by, 17: 11397
ionization by electron bombardment close to threshold, 17: 10707
ionization of, by electrons, calculation of S-cross section for, 17: 11359(T)
meson($\mu^-$) capture rate in liquid, estimation of, 17: 11480 (LNF-62/109)
monitoring for radioactivity, 17: 10900(R) (NP-12363)
neutron slowing-down in, renewal theory for, 17: 11603
oxidation on rotating disk electrode, limiting diffusion and ionization currents for, 17: 10628
plasma of, penetration by electromagnetic waves, 17: 11885
positron elastic scattering by atomic, zero-order partial wave shifts for, 17: 11328 (TID-15769)
positron scattering by atomic, at 11.0 to 54.4 ev, 17: 11390
radiation effects on liquid, 17: 11264(R) (NP-12388)
radioinduced energy storage in liquid, 17: 11262 (NARF-62-15T)
radiolysis effects on formation of benzene from acetylene, 17: 10698
radiolytic production of, in aqueous uranyl sulfate, 17: 11952 (NAA-SR-7086)
reactions with deuteron beams, 17: 10514(R) (ORNL-3320(p.104-25))
reactions with sulfates, 17: 10246(R) (ORNL-TM-403)
separation from deuterium and deuterium hydride on activated alumina, chromatographic, 17: 11057
separation from tritium, 17: 10240(R) (NP-12208)
sorption by niobium and titanium mixed hydrides, 17: 11237
spectra of, profiles of Stark-broadened Balmer lines in plasma, 17: 11860
thermoelectric effects on nickel and platinum, 17: 11435
yield in radiolytic and thermal decomposition of borazole, 17: 10700

**HYDROGEN ION CONCENTRATION**
control in high-pH aqueous systems by ion exchange, 17: 10499 (HW-SA-2595)

**HYDROGEN IONS**
adsorption on ferric oxide, isotherms for, 17: 11091(R) (MITS-49)
charge and radius effects of hydrated, on radiation stability of ion exchange resins, 17: 10719
charge exchange in electrostatic generators, neutral particle production in, 17: 10928
dissociation of molecular, 17: 10604(R) (TID-17724)
dissociation of negative, in cyclotrons, 17: 11799 (TID-17617)
energy levels of, 20-parameter eigenfunctions and energies of $2^1S$ states of, 17: 11751
ionization of helium by, 17: 10240(R) (NP-12208)

**HYDROGEN ISOTOPES**
exchange between ammonia and hydrogen gas, 17: 11058

**HYDROGEN ISOTOPES H-5**
production in (γ,2p) reactions on lithium-7, 17: 11728

**HYDROGEN PEROXIDES**
formation in water radiolysis, mechanism of, 17: 10686
magnetic resonance of irradiated, 17: 10514(R) (ORNL-3320(p.104-25))
oxidation by ceric sulfate, kinetics of, 17: 10631
photolysis of, effects of dissolved hydrogen and oxygen, 17: 10509(R) (ORNL-3320(p.30-46))
photolysis of, reactions of free radicals induced in, 17: 10679 (TID-15898)
production in oxygen reduction on film-covered zirconium, 17: 10623

**HYDROGEN SULFIDES**
radiation effects, 17: 10243 (NP-12381)

**HYDROGEN SYSTEMS**
Ar–H, electric discharge in, 17: 10240(R) (NP-12208)
He–H, electric discharge in, 17: 10240(R) (NP-12208)
H–U, calculations of integral and partial thermodynamic functions for, 17: 10607 (UCRL-10189)
H–Xe, characteristics of electric discharge in, 17: 11431
H–Zr, calculations of integral and partial thermodynamic functions for, 17: 10607 (UCRL-10189)
H–Zr, thermal stability, 17: 11817

**HYDROLYSIS**
of rare earth carbides, 17: 10591 (IS-499)

**HYDROMAGNETIC WAVES**
coupling to electromagnetic waves at plasma discontinuity, 17: 11850

**HYDROXYL RADICAL**
effects in diluted aqueous solutions, comparison with x-ray effects, 17: 10717

**HYPERONS**
annihilation on antibaryons, distributions from, 17: 11547
model for baryon-isobar excited states, 17: 11557
resonances based on static strong-coupling approximation, 17: 11532

**HYPERONS (Λ)**
interactions with protons, cross section for elastic, 17: 11533
production in meson (K) reactions in emulsions at 790 Mev/c, 17: 10240(R) (NP-12208)

**HYPERONS ($\Lambda^0$)**
production in meson ($K^-$)-proton interactions, 17: 11560

**HYPERONS (Σ)**
production in meson ($K^-$)-proton interactions, 17: 11560

**HYPERONS ($\Sigma^0$)**
decay of, ($\Lambda^0+\gamma$), 17: 11488 (NP-12499)

**HYPERONS ($\Xi^-$)**
interactions with protons at rest, 17: 11567
spin, 17: 11299(R) (ANL-6612)
spin measurement from decay angular asymmetry, 17: 11545

# I

**IMAGE BRIGHTNESS INTENSIFIERS**
design of high-voltage dividers for, 17: 10907 (TID-15860)

**IMMUNITY**
in irradiated mice, role of thymus in recovery of, 17: 10412
radiation effects on *Trichinella spiralis*, in mice, 17: 10424
radiation effects on reactions of, in postoperative corneal grafts, 17: 10439
radiation effects on, in chimeras given bone marrow injections, 17: 10474
radiation effects on reactions to injected lympho-reticular cells in mice, 17: 10289
reactions to injected lymph cells in radiation chimeras, 17: 10473

**IMPACT SHOCK**
effects on structural materials, 17: 11937(R) (ARF-4132-16)

**IN-PILE LOOPS**
design and construction of, for studies of steam–water spray reactor cooling, 17: 11942(R) (EURAEC-476)
development of, in GETR, 17: 11086(R) (GEAP-3771-4)
operation of, for evaluation of steam–water spray as reactor coolant, 17: 11941(R) (EURAEC-475)

**INCONEL X**
brazing and welding of, criteria for, 17: 11163 (DMIC-181)
radiation effects on mechanical properties, 17: 11129

**INDIUM**
nuclear quadrupole resonance, 17: 10592 (IS-520)
proton reactions at 2.9 Bev, nuclear charge distributions in, 17: 11727

**INDIUM ALLOYS**
superconductivity transitions in, ideal, 17: 11376

**INDIUM ISOTOPES In-111**
production and separation of, method for, 17: 10676 (NP-12231)

**INDIUM ISOTOPES In-115**
neutron resonance integral, 17: 11979(R) (DP-805)

**INDIUM ISOTOPES In-117**
half lives of energy levels of, 17: 11696
isomer yields in (p,α) reactions in tin-120 at 12 and 18 Mev, 17: 11697
yields in (p,α) reactions on tin-120, 17: 11696

**INDUSTRIAL HYGIENE**
status of meteorological knowledge as factor in pollution control, 17: 10843 (BNL-6538)
training programs, 17: 10854 (HW-SA-2565)

**INDUSTRIAL MANAGEMENT**
PROLOG technique for long-range project planning, 17: 11073 (UCRL-10491)
**INFECTIONS**
in mice, effects of deuterium oxide on mousepox, 17: 10285
radiation effects on immunity to *Trichinella spiralis*, in mice, 17: 10424
radiation effects on mortality in mice with *Trichinella spiralis*, 17: 10431
**INFRARED RADIATION**
effects on genetics of *Neurospora crassa* exposed to nitrogen mustard, 17: 10455
**INOR-8**
corrosion by carbon tetrachloride–chlorine/oxygen, 17: 10246(R) (ORNL-TM-403)
welding by shielded consumable-electrode process, 17: 11169 (Y-1409)
**INSECTS**
labeling of larval and adult mosquitoes with phosphorus-32, 17: 10423
radiation effects on kinetochore in, 17: 10404
**INSPECTION AND CONTROL**
development of portable di-octyl phthalate tester for, of high-efficiency filters, 17: 10922
**INSTRUMENTATION**
bubble chamber track-centering device, 17: 11000 (BNL-6094)
characteristics of linear variable differential transformer gage heads, standardization of, 17: 10904 (SCTM-100-62-81)
development for Project Vela Uniform, 17: 10819(R) (AD-278217)
**INSTRUMENTS**
design for measuring Seebeck coefficients, 17: 11316 (NAA-SR-Memo-6741)
development for scintigram image contrast intensification, 17: 11046
noise, 17: 10915 (TID-17749)
**INTERNAL CONVERSION**
penetration effects in magnetic-dipole L-shell, 17: 11618 (BNL-6647)
**INTESTINE**
movement of food in rat, tracer study using yttrium-91, 17: 10281
radiation dose to rectum from therapy of carcinoma of uterine cervix, 17: 10259
radiation effects on thymidine metabolism, effects of AET treatment, 17: 10486 (TID-15931)
radiation effects on survival of rats, effects of surgical isolation of, 17: 10378
radiosensitivity of epithelium, 17: 10355 (BNL-6113)
sorptive capacity of dogs, effects of centimeter band radio waves on, 17: 10315
**IODATES**
nuclear quadrupole resonance, 17: 10592 (IS-520)
**IODIDES**
nuclear quadrupole resonance, 17: 10592 (IS-520)
use for refining niobium, 17: 10635
**IODINE**
measurement of butanol extractable, in children exposed to atomic explosion *in utero* in Nagasaki, 17: 10371
neutron reactions (n,γ), electric field separation of recoil products from, 17: 10702
nuclear quadrupole resonance, 17: 10592 (IS-520)
scavenging effects on carbon-11 recoil reactions with cyclohexane, yields in, 17: 10701
**IODINE ISOTOPES I-126**
beta decay correlations in, 17: 11698
**IODINE ISOTOPES I-128**
beta decay, measurement of absorption factor and other factors in, 17: 11622 (NP-12439)
**IODINE ISOTOPES I-131**
determination in milk by anion exchange, spectrometric, 17: 10554
determination in thyroid gland by external counting, 17: 10849(R) (HW-73337(p.29-76))
dietary availability from milk and other foods, 17: 10310(R) (TID-17789)
energy of, from 23-Mev deuteron fission of uranium-238, 17: 11646 (UCRL-10193)
solutions of, effects of aging, oxidations, and ultraviolet radiation on, 17: 10682
trapping methods for, 17: 10844 (CEA-Bib-29)
uptake by thyroid gland, calibration system for measurements, 17: 10343
use in evaluation of oil-water emulsions, 17: 10884
**IODINE ISOTOPES I-135**
yields from uranium-235 thermal fission, 17: 11746
**ION BEAMS**
analysis of, pulsed electrostatic analyzer for, 17: 11010 (TID-16311)
bunching of, equipment for, 17: 11814
decrease of bunch duration and recurrence in cyclotrons, 17: 11779 (BNL-767(p.278-87))
**ION EXCHANGE MATERIALS**
agitated beds of, method for prediction of loss curves for, 17: 10763
efficiency of Amberlite 200 for isotope separations, 17: 10508(R) (ORNL-3320(p.22-9))
elution of uranium(VI) from, effects of pH on, 17: 10660
performance of Permutit SK for plutonium recycling, 17: 11108(T,R) (EURAEC-307)
radiation effects on stability of, effects of charge and radius of hydrated exchange ion on, 17: 10719
radiation stability of Wofatites, 17: 11276
sorption of cesium-137 on zeolite, thermal conditions for, 17: 12040 (HW-74712)
thermodynamic potential of, effects of swelling on, 17: 11252
**ION EXCHANGE PROCESSES**
development, 17: 10511(R) (ORNL-3320(p.56-82))
development for separation of actinides, 17: 10771
use in separation of trivalent rare earths from divalent metal ions, 17: 10734 (IS-508)
**ION EXCHANGERS**
development for absorption of fission products from waste solutions, 17: 10851(R) (HW-73337(p.158-237))
**ION PAIR PRODUCTION**
in air, energy requirements from cobalt-62, 17: 10849(R) (HW-73337 (p.29-76))
**ION PUMPS**
design and operation for ultrahigh vacuums, 17: 10944
**ION SOURCES**
design for mass spectroscopy, photoionization, 17: 10567
design for mass spectrometers, 17: 10942
design for mass spectrometers, 17: 10943
development of, for rocket propulsion, 17: 11302 (ASD-TR-61-150(Pt.II))
development of, using resistance-strip electron multipliers, 17: 10898(R) (N62-10115)
plasma contraction in, by inhomogeneous field, 17: 11777 (BNL-767 (p.224-53))
preparation and properties of tungsten, for ion propulsion systems, 17: 11080 (ASD-TDR-62-756)
**IONIZATION**
measurement of cross-section for electron, design of crossed-beam method for determining, 17: 11319 (NP-12358)
measurements in tissue-equivalent chamber, determination of relative biological efficiency by, 17: 10448
photo-, method of calculating cross sections for, 17: 10681(R) (TID-17743)
**IONIZATION CHAMBERS**
design for use in power reactors, 17: 10986
design of α-c, 17: 11026
design of pressure, for industrial gamma radiation measurements, 17: 11015
design of, with controllable electrode voltages, 17: 10967
development of argon-hydrogen filled, for measuring fast neutrons, 17: 11035
development of, for monitoring flowing liquid hydrogen, 17: 10900(R) (NP-12363)
electron accumulation and ion mobility in nitrogen-filled, effect of oxygen and water vapor additions, 17: 11047
filling helium-3, description of system for, 17: 10934
testing of, for use as gamma indicators, 17: 10889 (AD-252467)
**IONOSPHERE**
effects of high-altitude thermonuclear explosion on, 17: 10828
electron density perturbations in, by satellites, 17: 11451
plasma density in, measurement of, 17: 11447
**IONS**

acceleration and extraction of, in cyclotron with azimuthally varying magnetic field and regulated energy, 17: 11778 (BNL-767(p.254-77))
acceleration in electrostatic generators, measurements of, 17: 10928
cyclotron frequency in plasma, 17: 11851
detection and identification of, foil-detector system for, 17: 11008 (TID-16174)
diffusion across magnetic fields in plasma, anomalous, 17: 11857
diffusion in plasma, 17: 11890
distribution in toroidal electric discharge, 17: 11884
drift velocity in argon and hydrogen, 17: 11430
energy measurement in plasma, design of instrument for, 17: 10897 (MATT-121)
interactions with atoms in gases, scattering and charge exchange cross sections for, 17: 11340(T) (AEC-tr-5615)
oscillations in cesium and mercury diodes, 17: 11441
oscillations in stationary plasma, longitudinal, 17: 11888
radiation intensity of impurity, plasma energy losses from, 17: 11855
reactions at high energies, neutron transfer in, 17: 11492 (TID-16044)
recombinations with electrons in noble gas discharge, 17: 11384

**IRIDIUM ALLOYS**
Ir–Mo, superconducting isotope effect in, 17: 11375
Ir–Ta, hardness, 17: 11093(R) (NMI-2112)

**IRON**
alloying effects on hardness of beta-quenched uranium, 17: 11097(R) (NMI-7257)
alloying effects on oxidation of zirconium beryllide, 17: 11082(R) (BBC-113)
binding in indium, evidence for anharmonic, 17: 11230
determination in alloys, 17: 10539 (TID-16296)
determination in aluminum as trace impurity, activation, 17: 10546
determination in aluminum, x-ray spectroscopic, 17: 10571
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
diffusion in beta uranium, 17: 11079 (ANL-FGF-334)
dissolution rate in liquid aluminum, 17: 10577 (ANL-FGF-292)
electric properties of electrodeposited, 17: 10512(R) (ORNL-3320 (p.83-97))
electrochemical properties of, effect of hydrogen on, 17: 10512(R) (ORNL-3320(p.83-97))
gamma scattering at 7 and 17 Mev, Delbruck, 17: 11745
mechanical properties and structure of Armco, relations with temperature, 17: 11188(R) (EURAEC-485)
neutron critical scattering in, 17: 11222
radiation effects of neutrons on atom displacements in, 17: 11087(R) (GEMP-19A)
separation from sulfate solutions by solvent extraction using bis-(2-ethylhexyl) phosphoric acid, 17: 10766
separation of copper and uranium from trivalent, by ion exchange chromatography, 17: 10752(T) (GAT-Z-5035)
solvent extraction of trivalent, from purex wastes, 17: 10740(R) (ORNL-TM-181)

**IRON ALLOYS**
corrosion studies of, technical progress review, 17: 11129
passivation behavior, 17: 10512(R) (ORNL-3320(p.83-97))
Al–Fe, ductility, 17: 11129
Al–Fe, magnetic properties, 17: 10240(R) (NP-12208)
Al–Fe–U, mechanical properties and structure of, 17: 11096(R) (NMI-7256)
Al–Fe–U, mechanical properties and radiation effects, 17: 11095(R) (NMI-7254)
Be–Fe, magnetic properties of, 17: 10240(R) (NP-12208)
Fe–Mo, thermal expansion of solid solutions of, anomalies in, 17: 11238
Fe–Ni, allotropic transformation in, 17: 10240(R) (NP-12208)
Fe–Ni, anisotropic energy of electron irradiated, 17: 11274
Fe–Tc, phase studies on, 17: 11220
Fe–W, thermal expansion of solid solutions, anomalies in, 17: 11238

**IRON CARBONYLS**
thermodynamic properties at high temperatures, 17: 10580 (BM-RI-6155)

**IRON CYANIDES**
analytical use for sorption of precipitates in cesium-134 solutions, 17: 10706

**IRON FILMS**
electron polarization by magnetized, 17: 11577

**IRON FLUOSILICATES**
electric field gradients of, effects of temperature on, 17: 11759

**IRON IONS**
separation from metal ions by extraction using 8-quinolinethiol, 17: 10768

**IRON(II) IONS**
radioinduced oxidation of, polarographic method for determination of yields in, 17: 10569

**IRON(III) IONS**
charge and radius effects of hydrated, on radiation stability of ion exchange resins, 17: 10719

**IRON ISOTOPES Fe-54**
neutron capture cross sections and resonances for, 17: 11805(R) (TID-17728)

**IRON ISOTOPES Fe-56**
neutron capture cross sections and resonances for, 17: 11805(R) (TID-17728)

**IRON ISOTOPES Fe-57**
electric quadrupole moment of 14.4-kev level, 17: 11759
energy levels of, isomeric shifts in, 17: 11691
gamma emission of bound, temperature dependence in recoil-free, 17: 11230
gamma transitions in, E2/M1 mixing ratio of, 17: 11701
Mössbauer effect in iron silicides, 17: 11381
neutron capture cross sections and resonances for, 17: 11805(R) (TID-17728)
proton reactions (p,2p) at 400 Mev to 6.2 Bev, cross sections and excitation functions for, 17: 11650 (UCRL-10531)

**IRON ISOTOPES Fe-59**
gamma emission in man, method for measurement of, 17: 10271
production and separation of, method for, 17: 10676 (NP-12231)
radiation effects on clearance of, from blood plasma in bone marrow in rats, 17: 10413

**IRON OXIDES**
adsorptive properties for organic and water vapors, 17: 11091(R) (MITS-49)

**IRON SILICIDES**
internal magnetic fields, isomer shifts, and relative abundances of iron sites in, 17: 11381

**IRON(II) SULFATES**
radioinduced oxidation of, comparison with potassium ferrocyanide, 17: 10692

**IRON SYSTEMS**
Fe–Si, magnetic properties, 17: 10240(R) (NP-12208)

**IRRADIATION FACILITIES**
description of Riso accelerator, 17: 11812
design of pneumatic system for rapid transfer of irradiated solution to container, 17: 10784 (USNRDL-TR-601)
development of commercial, for sterilization of disposable hypodermic syringes, 17: 10266

**ISOPROPYL ETHER**
radiolysis of, effects of dose rate and temperature on yields from, 17: 10705

**ISOTOPE EFFECTS**
Gibbs statistics of, in ideal and real gaseous systems, 17: 10655

**ISOTOPE SEPARATION METHODS**
centrifugal, theory of countercurrent, 17: 11053 (TID-15764)
centrifugation, theory of, 17: 11054 (UVA-279-63U)
chemical processes, 17: 10508(R) (ORNL-3320(p.22-9))
development, 17: 11332(R) (TID-17590)
effusion, dynamics of, 17: 11061
effusion, efficiency improvement by addition of light gas, 17: 11062
electromagnetic, electrode displacement in, 17: 10240(R) (NP-12208)
thermal diffusion, concentration effects in, 17: 11059

**ISOTOPES**
abundances of, design of Fabry-Perot spectrometer for measurement of, 17: 10969
Gibbs statistics of ideal and real gaseous systems of, in thermodynamic equilibrium, 17: 10655
separation by gaseous diffusion process, review of Swedish work on, 17: 11060

**ISOVALERONE**
solvent properties for niobium, 17: 10714
**ITALY**
radioactivity in Lake Maggiore fish, 17: 10349
**ITALY (TUSCANY)**
beryllium deposits in Mount Capanne (Elba) and the Island of Giglio, 17: 10827

## J

**JOINTS**
fabrication of accelerator-waveguide, 17: 11798(R) (TID-17221)

## K

**KAOLINITES**
adsorptive properties for polyacrylamide, 17: 11091(R) (MITS-49)
**KEROSENE**
analysis for TBP by x-ray absorption, 17: 10536 (NP-12398)
extraction performance in nitric acid, effects of TBP, 17: 10739(R) (ORNL-TM-27)
kerosene–TBP–$UO_2(NO_3)_2$, analysis for free acidity, design of meter for, 17: 10972
**KETONES**
adsorption on hematite, isotherms for, 17: 11091(R) (MITS-49)
solvent properties for plutonium(IV) in nitrate medium, 17: 10758
**KIDNEYS**
radiation damage to, in rats, effects of cortisone on, 17: 10470
radiation effects on glomerular lesions in, pathogenesis of whole-body, 17: 10433
radiation effects on nephritis in man, therapeutic, 17: 10440
radiodiagnosis of disease in, by retention of mercury-203 labeled mercaptomerin sodium in plasma, 17: 10345
uranium injury effects on tubules of, in rats, 17: 10265
zinc distribution and turnover in, in rats, tracer study, 17: 10275
**KILNS**
control of continuous uranium trioxide producing, system development by simulation techniques, 17: 10723 (HW-SA-2433)
development and performance of fluidized-bed, 17: 12045 (TID-7646(p.3-19))
development of rotating ball-type, 17: 12047 (TID-7646(p.37-42))
**KRYPTON**
radiolysis effects on formation of benzene from acetylene, 17: 10698
**KRYPTON IONS**
sputtering gold by, energy of atoms in, 17: 11374
**KRYPTON ISOTOPES**
separation by thermodiffusion concentration distribution in tubes for, 17: 11059
**KRYPTON ISOTOPES Kr-83**
hyperfine structure of metastable state of, 17: 11692
**KRYPTON ISOTOPES Kr-85**
penetration range in aluminum and tungsten, 17: 11612 (AFOSR-2975)

## L

**LABORATORIES**
construction of low-background counting facility, evaluation of Portland cements for use in, 17: 11903 (UCRL-10475)
description of, for carbon-14 age measurements, 17: 10834
description of Lucas Heights, 17: 10254
description of Riso metallurgy, 17: 11121
design of gamma radiation standard, in Sweden, 17: 10785
design of ORNL mobile radiation, 17: 10877
disassembly of plutonium–contaminated, 17: 10866 (TID-16203)
**LABORATORY EQUIPMENT**
design of apron for radiation protection, 17: 10873
**LANTHANUM**
binding to blood serum proteins and nucleic acids, tracer study, 17: 10307 (TID-17522)
determination in aluminum as trace impurity, activation, 17: 10546
determination using diammonium-5,5'-indigo disulphonate, 17: 10568
discovery and development of, review on, 17: 10618
distribution in tissues of mice of ionic and chelated form, tracer study, 17: 10308 (TID-17542)
reactions with ammonium, potassium, and sodium salts, precipitation, 17: 10621
superconductivity of foils, 17: 11251
**LANTHANUM ALLOYS**
Gd–La, phase studies, 17: 11186 (DRI-2080)
Gd–La, superconductivity of foils of, 17: 11251
La–Y, phase studies, 17: 11186 (DRI-2080)
**LANTHANUM ISOTOPES La-137**
nuclear spin of the 455-kev level, 17: 11705
**LANTHANUM ISOTOPES La-139**
nuclear spin of 166-kev level, 17: 11705
**LANTHANUM ISOTOPES La-140**
determination in radiation source mixture with molybdenum-99, from decay data, 17: 10547
**LANTHANUM OXIDES**
$B_2O_3$–$La_2O_3$, reduction by carbon, 17: 10662
**LANTHANUM SELENIDES**
thermoelectric properties of sesqui-, 17: 11292 (AD-277043)
**LEAD**
analysis of, mass spectrometric, 17: 10240(R) (NP-12208)
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
determination of, in ore samples by gamma or x ray absorption, 17: 10564
electric resistivity of, effects of lattice vacancies on, 17: 11231
gamma attenuation in, calculation of, 17: 11904
gamma scattering at 7 and 17 Mev, Delbruck, 17: 11745
neutron attenuation and capture radiation in slabs of, 17: 11900 (NARF-62-16T)
neutron capture by, gamma emission in fast, 17: 11659
neutron transport in, 17: 11598 (TID-16304)
proton reactions (p,n), model for resonance peaks in, 17: 11681
radiation effects on superconductivity in, alpha, 17: 11291
x-ray (M) emission in polonium alpha decay, 17: 11616 (BNL-6166)
**LEAD ALLOYS**
Bi–Pb, a-c losses in superconducting, 17: 11372
**LEAD CRYSTALS**
growth of single, 17: 10502 (IS-542)
**LEAD ISOTOPES Pb-207**
proton inelastic scattering cross sections, 17: 11720
**LEAD ISOTOPES Pb-208**
energy levels ($3^-$), effects of configuration mixing on, 17: 11720
**LEAD ISOTOPES Pb-214**
pollution of atmosphere by, method for determining, 17: 10560
**LEAD NITRATES**
salting-out properties in uranyl nitrate extraction from aqueous solutions, 17: 10770
**LEAD OXIDES**
solid-phase reactions of, at high pressures, 17: 10503 (NP-12359)
**LEAD TELLURIDES**
fabrication and processing of, statistical analysis of variables in, 17: 11314 (NAA-SR-7288)
thermoelectric properties at high temperatures, measurement of, 17: 11316 (NAA-SR-Memo-6741)
**LEAK DETECTORS**
development of, for x-ray tubes, 17: 11018
**LECTURES**
on group theory in quantum mechanics, 17: 11906 (NP-12434)
**LEPTONS**
currents of, classification of, 17: 11479 (LNF-62/98)
search for pairs of, meson resonance decay in, 17: 11642(R) (TID-17720(p.98-100))
**LEUKEMIA**
induced in rats by methylcholanthrene and x radiation, transmission of, 17: 10258
pathology of associated anemia, tracer study, 17: 10341
radioinduced in mice, 17: 10360 (TID-15850)
radioinduced in mice, x, 17: 10406
**LEUKOCYTES**
protective effects of isogenic injections of, on lethally irradiated rats, 17: 10437

protective effects of isologous leukemoid, on radiation injuries in mice, 17: 10283
radiation effects on motility of, 17: 10445
radiation effects on lipid metabolism, tracer study, 17: 10365(R) (TID-17692)
radiosensitivity of cystamine-protected, 17: 10487
**LIFE SPANS**
radiation effects in mice, 17: 10360 (TID-15850)
radiation effects on *Drosophila melanogaster*, 17: 10277
**LIGHT**
red-shift theory, 17: 11305 (IFT-1)
scattering by electron beams, 17: 11550
**LINEAR ACCELERATORS**
design of high-intensity proton, 17: 11332(R) (TID-17590)
development of electron, 17: 11798(R) (TID-17221)
focusing requirements for Stanford two-mile, discussion of, 17: 11793 (SLAC-2)
research at Rensselaer, 17: 11805(R) (TID-17728)
**LIPIDS**
radiation effects on metabolism in leukocytes, 17: 10365(R) (TID-17692)
**LIPOPROTEINS**
role in biosynthesis of protein in chloroplasts, tracer studies, 17: 10314
**LIQUID FLOW**
heat transfer from internally heated rods in, 17: 10810
**LIQUIDS**
electric conductivity of, pressure analysis of, 17: 11364
neutron inelastic scattering by, 17: 11414
**LITHIUM**
analysis of, by delayed neutron emission from nitrogen-17, 17: 10534 (IA-784)
analysis of, mass spectrometric, 17: 10240(R) (NP-12208)
bremsstrahlung reactions (γ,p) at 335 Mev, 17: 11704
nuclear magnetic resonance saturation in, 17: 11392
nuclear quadrupole resonance, 17: 10592 (IS-520)
photoionization of, cross sections for, 17: 10681(R) (TID-17743)
reactions with water vapor at 20 to 45°C, 17: 10622
**LITHIUM BROMIDES**
self-diffusion effects of, on water at 25°C, 17: 10613
**LITHIUM CARBONATES**
$Li_2CO_3$–$K_2CO_3$–$Na_2CO_3$, heat transfer to uranium from molten, 17: 10805 (Y-1410)
**LITHIUM CHLORIDES**
$AlCl_3$–LiCl–KCl, immiscibility gap in molten phase, 17: 10587 (HW-SA-2621)
**LITHIUM FLUORIDE CRYSTALS**
deformation and fracture parameters, 17: 11197 (UCRL-10435)
luminescence of, in hexavalent uranium-activated, piezospectroscopic effect in, 17: 11360(T)
radioinduced expansion in, mechanism of, 17: 11266 (TID-15896)
**LITHIUM FLUORIDES**
precipitation of, lithium isotope separation in, 17: 10240(R) (NP-12208)
LiF–KF, molar enthalpies of mixing in, 17: 10514(R) (ORNL-3320 (p.104-25))
**LITHIUM HYDRIDES**
use as nuclear rocket propellant, effects of lithium-6 and -7 on, 17: 12034 (NP-12353)
**LITHIUM IODIDES**
ionic association in butanol–hexane solutions, theory of, 17: 10656
**LITHIUM ION BEAMS**
reactions with carbon-12, 17: 11718
**LITHIUM IONS**
energy levels of, 20-parameter eigenfunctions and energies of $2^2S$ states of, 17: 11751
exchange and migration in lithium nitrate solutions, 17: 10659
**LITHIUM ISOTOPES**
gamma reactions on, beta activity from, 17: 11728
separation in lithium fluoride precipitation, 17: 10240(R) (NP-12208)
**LITHIUM ISOTOPES Li-6**
analysis of, by delayed neutron emission from nitrogen-17, 17: 10534 (IA-784)
distribution in lithium hydride propellants, effects on nuclear rocket performance, 17: 12034 (NP-12353)
neutron reactions (n,α) in, electron microscopy observation of, 17: 11615 (BNL-6082)
neutron reactions (n,2n) at 10.2 and 14.1 Mev, cross sections for, 17: 11722
**LITHIUM ISOTOPES Li-7**
diffusion through tungsten, coefficient for, 17: 11206
distribution in lithium hydride propellants, effects on nuclear rocket performance, 17: 12034 (NP-12353)
gamma reactions (γ,2p) on, hydrogen-5 from, 17: 11728
neutron reactions (n,2n) at 10.2 and 14.1 Mev, cross sections for, 17: 11722
production by neutron reactions (n,α) with boron-10, energy of, 17: 11670
proton reactions (p,2p), cross sections for, 17: 11703
**LITHIUM NITRATES**
salting-out properties in uranyl nitrate extraction from aqueous solutions, 17: 10770
$LiNO_3$–$KNO_3$, properties of cobalt-II ions in, effects of bromides, chlorides, and fluorides on, 17: 10605(R) (TID-17816)
**LIVER**
immunological tolerance of fetal cells of, in radiation chimeras, 17: 10270
pathological effects of plutonium-239 in dogs, 17: 10328
radiation effects on function of, in cancer patients, 17: 10464
radiation effects on enzyme systems, 17: 10478(R) (NP-12251(p.1-11))
radiation effects on enzyme systems, 17: 10479(R) (NP-12251(p.12-21))
radiosterilized diet effects on cytochrome oxidase activity in, in successive rat generations, 17: 10350
zinc distribution and turnover in, in rats, tracer study, 17: 10275
**LOS ALAMOS TURRET REACTOR**
development, 17: 11984(R) (LAMS-2835)
**LUNGS**
radiation effects on development of embryonic cells in tissue culture, 17: 10420
radioinduced pneumonitis in, in rats, 17: 10377
radioinduced tumors in mice, 17: 10476
storage of inhaled uranium in, effects on urinary excretion, 17: 10311 (Y-KB-1)
ventilation measurements using radiopulmonogram, 17: 10280
**LUTETIUM**
determination in aluminum as trace impurity, activation, 17: 10546
electric conductivity of, from electron-phonon scattering in, 17: 11221
radioactivity induced in, neutron temperature measurement by, 17: 11586 (AAEC/TM-164)
**LUTETIUM ALLOYS**
electric conductivity at 4.2°K, residual, 17: 11367
Gd–Lu, electric conductivity, 17: 11190 (IS-477)
Lu–Tb, electric conductivity, 17: 11190 (IS-477)
Lu–Y, electric conductivity, 17: 11190 (IS-477)
**LYMPH**
radiation effects on corpuscles and proteic pattern in thoracic duct, 17: 10462
**LYMPH CELLS**
effects of injected, in radiation chimeras, 17: 10473
**LYMPH SYSTEM**
immune response in, 17: 10289
radiation and encephalomyelitis virus effects on, in guinea pigs, 17: 10427
radiation effects on mouse, x, 17: 10406

# M

**MAGNESIUM**
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
deuteron scattering at 3 to 30 Mev, optical model analysis of, 17: 11676
dislocations in, electron microscopic studies, 17: 11182 (AROD-3394.1)
electric resistivity of, effects of lattice vacancies on, 17: 11231
photoionization of, cross sections for, 17: 10681(R) (TID-17743)
reactions with ammonium nitrate and oxalate and potassium and sodium sulfates, precipitation, 17: 10621
separation from trivalent rare earths by cation exchange, 17: 10734 (IS-508)
**MAGNESIUM ALLOYS**

Al–Cu–Mg, thermal capacity and conductivity at –180 to +200°C, 17: 11200 (USNRDL-TR-599)
Al–Mg, deformation of, piezoelectric pulse measurements during, 17: 11250
Al–Mg, fatigue test values of, 17: 11245
Al–Mg–Zn, temperature dependence in stress corrosion, 17: 11139
Cd–Mg–Zn, creep properties, 17: 11179 (AERE-M-1149)

**MAGNESIUM CHLORIDES**
$MgCl_2$–KCl–NaCl, solvent properties for cerium and uranium from bismuth–magnesium alloy at 500°C, 17: 10581 (BNL-639)

**MAGNESIUM IONS**
energy levels of, 20-parameter eigenfunctions and energies of $2^2S$ states of, 17: 11751

**MAGNESIUM ISOTOPES Mg-24**
alpha reactions (α,γ) at 1.5 to 3.5 Mev, 17: 10240(R) (NP-12208)
proton elastic and inelastic scattering at 6.9 Mev, angular distribution from, 17: 11743

**MAGNESIUM ISOTOPES Mg-25**
energy level transitions in, 17: 11660

**MAGNESIUM ISOTOPES Mg-26**
energy levels, 17: 11299(R) (ANL-6612)
proton reactions (p,γ), 661-kev resonance spectra from, 17: 11680
proton reactions (p,γ) at 2.81 Mev, 17: 11686

**MAGNESIUM NITRATES**
salting-out properties in uranyl nitrate extraction from aqueous solutions, 17: 10770

**MAGNESIUM OXIDES**
radiation effects on catalytic activity, 17: 10672 (BNL-6097)
thermal capacity and conductivity at –180 to +200°C, 17: 11200 (USNRDL-TR-599)
$Al(OH)_3$–$Mg(OH)_2$, crystallization in dialyzed medium, composition and structure of, 17: 10619

**MAGNESIUM SULFATES**
reduction by hydrogen, 17: 10246(R) (ORNL-TM-403)
self-diffusion effects of, on water at 25°C, 17: 10613

**MAGNETIC FIELDS**
bibliography on production and use of strong pulsed, 17: 11442
characteristics of magnetohydrodynamic, 17: 11365
Coulomb interaction in plasma in, uniform, 17: 11869
current flux function for axi-symmetric, 17: 11355
effects on angular correlations of nuclear radiation, 17: 11386
electron Coulomb interactions in, 17: 11538
particle dynamics in longitudinally varying, adiabatic approximation for, 17: 11795 (SLAC-4)
particle-focusing properties of cylindrically symmetric, 17: 10935
plasma diffusion in, 17: 11881
plasma diffusion in, 17: 11890
plasma injection into, emission light separation during, 17: 11854
plasma loop motion in, 17: 11892
plasma oscillations in non-uniform, 17: 11847
plasma stability in homogeneous, without longitudinal current, 17: 11889
production of, current-density calculations for, 17: 11440
properties of, from helical coils, 17: 11879
second-order effects of nuclear, 17: 11617 (BNL-6205)

**MAGNETIC MATERIALS**
theory of NMR modes in, 17: 11379

**MAGNETIC MIRROR MACHINES**
development of Scylla IV, 17: 11831(R) (LAMS-2816)
x-ray production in Scylla I, 17: 11831(R) (LAMS-2816)
Zeeman effect measurement in Scylla I, 17: 11831(R) (LAMS-2816)

**MAGNETIC MIRRORS**
plasma loss through apertures in, with field increasing toward the periphery, 17: 11841(T) (AEC-tr-5620)

**MAGNETIC PROPERTIES**
temperature dependence of, in superconductors, 17: 11369

**MAGNETISM**
theory of spin couplings in, Heitler-London method of calculation, 17: 11420

**MAGNETITE CONCRETES**
shielding properties of, tests on, 17: 11218

**MAGNETITES**
magnetic coupling in, temperature dependence of, 17: 11222

**MAGNETOHYDRODYNAMIC CELLS**
bibliography, 17: 11322 (NP-12429)

**MAGNETOHYDRODYNAMICS**
development of, using nonthermal ionization for use in nuclear power plants, 17: 12002
field mode concept in, 17: 11365
flow in magnetogasdynamic source, 17: 11830 (D1-82-0166)
flow in viscous, conducting, axially-symmetric systems, 17: 11438
magnetic-field and velocity distributions in fluid flows in, 17: 11352
plasma radial oscillations in pulsed electrodeless discharge, 17: 11892
stability of axially-symmetric, conducting, vortex flow between coaxial cylinders, 17: 11439
stability of axially symmetric motions in, 17: 11887

**MAGNETS**
alignment method for 300-Bev synchrotron, 17: 11786 (CTSL-36)
design and testing for 7-Bev accelerator, 17: 11762 (BNL-767(p.1-31))
measurements on Argonne BM-102 bending, magnetic, 17: 11804 (TID-17693)
use in systems for transport of secondary charged particle beams, 17: 11790 (PPAD-459F)

**MAIZE**
radiation effects on, neutron and x-ray seed exposure, 17: 10380
radioinduced somatic mutations in, effects of temperature on, 17: 10394

**MALONIC ACID**
decomposition of, uranyl sensitized photo-, 17: 10697

**MAN**
gamma emission from chromium-51 and iron-54 in, method for measurement of, 17: 10271
radiation death from accidental critical excursion, at Los Alamos, 17: 10874
radiation effects on nephritis in, therapeutic, 17: 10440
radiation effects on motility of leukocytes in, during therapy, 17: 10445
radiation effects on blood coagulation in, occupational, 17: 10446
radiation effects on liver function in, 17: 10464
radiation effects on metaphase/prophase ratio in, 17: 10411
radiation effects on thyroid gland cancer in children, therapeutic, 17: 10262
radiation effects on esophagitis in, therapeutic, 17: 10269
radiation effects on, exposed *in utero*, 17: 10875
radiation sickness in, effects of meclizine and pyridoxine on nausea and vomiting in, 17: 10489
radiotherapy of cerebral astrocytomata in, effects of whole-body hypothermia on, 17: 10438
radiotherapy of gynecological cancer in, late effects from, 17: 10372
radiotherapy of malignant tumors in, effects of adrenal steroid therapy on symptoms from, 17: 10268
radiotherapy of, using microspheres containing scandium-46 and yttrium-90, 17: 10288
radium distribution in, determined by whole-body counting, 17: 10300(R) (COO-226(p.71-77))
therapy of brain tumors in, effects of boron compounds for neutron capture, 17: 10282
toxic effects of beryllium on, clinical picture of, 17: 10313

**MANGANESE**
activating effects on luminescence of copper-activated zinc sulfide phosphor, 17: 11228(T)
determination in aluminum, x-ray spectroscopic, 17: 10571
determination in pure phosphorus, activation, 17: 10562
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
separation from metal ionic mixtures, electrochromatographic, 17: 10753
valence in brass from magnetic measurements, 17: 11297 (AE-95)

**MANGANESE ALLOYS**
Al–Mn–Ni, composition of X phase in, 17: 11249
Mn–Ni, conduction electron momentum in, electron–positron annihilation studies, 17: 11275
Mn–Tc, phase studies on, 17: 11220

**MANGANESE FLUORIDES**
magnetic properties of, 17: 11222

**MANGANESE IONS**
separation from metal ions by extraction using 8-quinolinethiol, 17: 10768

**MANGANESE ISOTOPES Mn-54**
production and separation of, method for, 17: 10676 (NP-12231)
**MANGANESE STEEL**
ductility of SOUDOTENAX-56, 17: 11171(T,R) (EURAEC-330)
**MANGANESE URANATES**
properties and structure, 17: 10633
**MARITIME REACTORS**
control of steam-cooled, analysis of, 17: 10985
design concept description of pressurized-water, 17: 12020
design of steam-cooled light-water-moderated, 17: 12006
design summary of NS *Savannah*, 17: 12015
development of 27,300-SHP power plant, 17: 11982(R) (GEMP-175)
**MASS SPECTROGRAPHY**
analysis of solids by, 17: 10943
development for gas analysis using photographic-plate ion detection, 17: 10537 (TID-15724)
summary of problems and equipment, 17: 10942
temperature effects in, 17: 10240(R) (NP-12208)
use of, in mass determinations, sources of error in, 17: 10614
**MASS SPECTROMETERS**
description and uses of, review, 17: 10942
design and performance of 360° tandem, 17: 10912 (TID-16312)
design and performance of high resolving power two-stage, 17: 10932
design and uses of cascade, 17: 10909 (TID-15951)
design of automatic scanning, 17: 10933
design of, combined with gas chromatograph, 17: 10558
design of SGAE, in Seibersdorf Reactor Center, 17: 10923
design of spark-source, 17: 10943
development of Lissajous, 17: 10898(R) (N62-10115)
development of pulsed-molecular-beam, 17: 10910 (TID-16209)
ion source design for, 17: 10567
measurement of two ion currents by pulse counting in, simultaneous, 17: 10908 (TID-15865)
quadrupole mass filter as analyzer in, operation, 17: 10945
**MASS TRANSFER**
between tube wall and fluid streams at Reynolds numbers from $10^4$ to $10^5$, 17: 10790 (AERE-R-4197)
**MATERIALS TESTING**
development for reactor materials, review of, 17: 11123
development of method for determining ductile-brittle transition temperature, 17: 11187(R) (EURAEC-447)
facilities for, at Riso metallurgical laboratory, 17: 11121
gamma sources for, 17: 10818
inspection of tungsten billets by gamma scanning, 17: 10816 (USNRDL-TR-602)
non-destructive, use of cesium-137 in, 17: 10817
of plutonium-base fuel elements, research program, 17: 10249(T,R) (EURAEC-301)
review of eddy-current techniques for, 17: 10815 (TID-16062)
ultrasonic techniques for, development of, 17: 11130
**MATHEMATICS**
equations for branching stochastic processes, 17: 10520(T) (NP-tr-946)
ergodic transformations and convergence theorem for measures, 17: 11068 (TID-15948)
many-body problems in, 17: 11482 (NP-12435(Pt.II))
particle-and-force models for calculations in fluid dynamics, 17: 11310 (LA-2806)
polynomials in spacing distribution functions, 17: 11063 (BNL-757)
random walks on plane net containing internal traps and trapping boundaries, 17: 11907 (TID-15885)
refraction arrival amplitude calculations by Zvolinskii's near-front approximation, 17: 11337 (UCRL-7146)
second order, formally self-adjoint uniformly elliptic differential operators, closed extensions of, 17: 11072 (UCRL-6648-T)
solution of one-group diffusion equation with variable coefficients, 17: 11590 (NP-12368)
theory of irreversible processes in many-particle systems, new method of, 17: 11832 (MATT-106)
**MATTER**
energy eigenvalues of, calculation by Green's functions, 17: 11357
spectral line widths in, calculation by Green's functions, 17: 11358
**MECHANICAL ENGINEERING**
design and evaluation of 3-dimensional strain rosettes, 17: 10783 (TID-17773)
**MECHANICS**
conformal transformations for velocities in excess of the velocity of light, 17: 11354
**MECLIZINE**
protective effects against nausea and vomiting in radiation sickness, 17: 10489
**MEDICAL SUPPLIES**
sterilization of, at Danish accelerator facility, 17: 11812
**MEDICINE**
procedures for radiation accidents, 17: 10876
radiation facilities and hygiene in dentistry survey of, 17: 10871
use of calcium-47 in, review on, 17: 10274
use of short-lived radioisotopes in, review on, 17: 10253
**MELTING**
techniques for, development of, 17: 11130
**MENDELEVIUM**
radiography of, techniques for, 17: 10535 (JINR-P-1118)
**MENDELEVIUM ISOTOPES Md-256**
separation by solvent extraction, comparison of hydrochloric and nitric acid systems with TBP, 17: 10735 (JINR-P-1075)
**MERCAPTOMERIN**
excretion of mercury-203 sodium salt of, in patients in cardiac failure, 17: 10345
**MERCHANT VESSELS**
nuclear propulsion of, review of advantages and disadvantages, 17: 10252
**MERCURY**
corrosive effects on metal at 900 to 1180°F, 17: 11129
electric discharge in vapor of, in diodes, 17: 11441
neutron capture by, gamma emission in fast, 17: 11659
nuclear quadrupole resonance, 17: 10592 (IS-520)
radiolysis effects on formation of benzene from acetylene, 17: 10698
reactions with hydrocarbons, effects of deuterium on quenching cross sections in, 17: 10685
separation from hydrochloric acid by solvent extraction using tri-*n*-butylphosphine sulfide, 17: 10754
separation from metal ionic mixtures, electrochromatographic, 17: 10753
structure of liquid, 17: 11232
**MERCURY SYSTEMS**
Hg–Ne, electron density and temperature in plasma of, 17: 11883
**MESIC ATOMS**
decay of ($K^-$), 17: 11512
**MESON SHOWERS**
distributions in ($\pi^0$), from cosmic-particle nuclear reactions, 17: 11454
**MESONS**
interactions with nucleons, effects of Regge poles on, 17: 11466 (CERN-62-33)
interactions with nucleous, strong, 17: 11568
interactions with nucleons, theory of radiation damping in, 17: 11916
production by 24-Bev proton beam incident on heavy concrete, 17: 11489 (ORNL-3367)
production in proton reactions with emulsion nuclei at 26.7 Bev/c, 17: 11611 (AD-277387)
production of $Y_1^1$, in meson K-nucleon interactions, 17: 11514
role of vector, in nucleon-nucleon spin-orbit interactions, 17: 11491 (TID-15930)
scattering of vector, amplitudes for, 17: 11509
**MESONS ($\eta$)**
decay branching ratio for, $(\pi^+ + \pi^- + \gamma/\pi^+ + \pi^- + \pi^0)$, 17: 11552
decay of, meson ($\pi$) emission in, 17: 11553
**MESONS (K)**
interactions at high energy, experimental and theoretical data on elastic, 17: 11507
interactions at high energy, cross section combinations for, 17: 11529
interactions with nucleons at high energy, total cross sections and Regge poles for, 17: 11493 (TID-16216)
interactions with nucleons, and meson ($Y_1^1$) scattering amplitude in, 17: 11514
interactions with antibaryons and baryons, effects on annihilation processes, 17: 11547
isovector charge, 17: 11542

prediction of, vector theory, 17: 11496 (TID-17742)
production and spin of ($K^*$), total cross sections and angular correlations for, 17: 11487 (NP-12488)
reactions in emulsions at 790 Mev/c, hyperon (Λ) production in, 17: 10240(R) (NP-12208)
spin of $K^*$ resonance, 17: 11542
**MESONS ($K^-$)**
interactions at high-energy, cross section combinations for, 17: 11529
interactions with protons, 17: 11487 (NP-12488)
interactions with protons, branching ratios for, 17: 11560
interactions with protons, angular distribution of mesons ($\pi^-$) produced in, 17: 11299(R) (ANL-6612)
**MESONS ($K^0$)**
mass difference ($K_1-K_2$), generation by second order weak interactions, 17: 11522
**MESONS ($K^+$)**
decay of, evidence for $K^+ \rightarrow \pi^+ + \pi^+ + \pi^- + \gamma$, 17: 11523
interactions at high-energy, cross section combinations for, 17: 11529
**MESONS ($K_{e3}$)**
decay of, angular distribution of products from, 17: 11484 (NP-12460)
**MESONS ($K_{e4}$)**
decay modes of, 17: 11534
**MESONS ($K_{\mu 4}$)**
decay modes of, 17: 11534
**MESONS ($K_{\pi 3}$)**
decay of, meson ($\pi$-$\pi$) resonance in, 17: 11528
decay of, meson ($\pi$) emission in, 17: 11553
**MESONS ($K^+_\gamma$)**
decay of, radiative, 17: 11536
**MESONS ($\mu$)**
pair production in meson ($\omega$) resonance decay, 17: 11642(R) (TID-17720(p.98-100))
production in meson($\pi$) decay, 17: 11471 (JINR-E-1120)
selection rule for (e-$\mu$) symmetry, 17: 11478 (LNF-62/97)
**MESONS ($\mu^-$)**
capture by carbon-12, 17: 11541
capture by lithium and oxygen, determination of, 17: 11331(R) (TID-17023)
capture rate in hydrogen (liquid), estimation of, 17: 11480 (LNF-62/109)
**MESONS ($\mu^+$)**
currents of, classification of, 17: 11479 (LNF-62/98)
**MESONS ($\omega$)**
decay modes of, 17: 11499 (UCRL-10089(Rev.))
decay of, production of lepton pairs in, 17: 11642(R) (TID-17720(p.98-100))
prediction of, vector theory, 17: 11496 (TID-17742)
**MESONS ($\omega^*$)**
production in proton interactions, theory for, 17: 11465 (BNL-6646)
**MESONS ($\pi$)**
decay of, meson($\mu$) and neutrino production in, 17: 11471 (JINR-E-1120)
interaction with nucleons, Riemann-Cauchy relations in theory of, 17: 11571
interactions at high energy, experimental and theoretical data on elastic, 17: 11507
interactions of, possibility of (4-$\pi$) resonance, 17: 11499 (UCRL-10089(Rev.))
interactions with nucleons, differential cross sections for mesons($\pi$) production by, 17: 11476 (JINR-P-1111)
interactions with mesons ($\pi$) in meson ($K_{\pi 3}$) decay, resonance, 17: 11528
interactions with nucleons, two-pion exchange terms in, for states T = 0 and T = 1, 17: 11544
interactions with nucleons, Regge poles in, 17: 11546
interactions with mesons ($\pi$), Regge poles in, 17: 11546
interactions with antibaryons and baryons, effects on annihilation processes, 17: 11547
interactions with nucleons, effects on nucleon properties, 17: 11558
interactions with mesons ($\pi$) and nucleons, effects on nucleon form factors, 17: 11559
interactions with protons, isotopic spin independence in, 17: 11561
interactions with nucleons, effect of meson ($\pi$-$\pi$) resonance in, 17: 11578
interactions with mesons ($\pi$), effects on meson ($\pi$)-nucleon interactions, 17: 11578
photoproduction on protons, 17: 11574
production by electron-proton interactions, 17: 11543
production in $\gamma$-$p$ interactions at 550 Mev, 17: 11564
production in mesons ($\pi$) -proton interactions, amplitudes in low-energy, 17: 11518
production in meson ($K^-$)-proton interactions, 17: 11560
production in neutrino-nucleon interactions, 17: 11563
production in peripheral nucleon-nucleon collisions, 17: 11515
spectra of, from mesons ($\eta$, $\tau$, and $\tau'$) decays, 17: 11553
**MESONS ($\pi^-$)**
capture by emulsion nuclei, single charged particle emission in, 17: 11679
capture of stopped, by nucleons, 17: 11687
interactions at high-energy, cross section combinations for, 17: 11529
interactions with protons, meson ($\pi$-$\pi$) amplitudes in low-energy, 17: 11518
interactions with protons, one-pion exchange model in, 17: 11535
production in meson ($K^+$) decay, 17: 11523
reactions ($\pi^-$, $\pi^-$n) with carbon-12 at 53 to 1610 Mev, cross sections and excitation functions for, 17: 11650 (UCRL-10531)
reactions ($\pi^-$, $\pi^-$n) in carbon-12, excitation function and study of mechanism for, 17: 11648 (UCRL-10312)
reactions with aluminum-27, copper, and zinc, cross sections and yields for, 17: 11650 (UCRL-10531)
reactions with xenon, at 8.4 Bev, meson ($\pi^0$) production in, 17: 11673
scattering in emulsions at 5.7 Mev/c, comparison of experimental and theoretical, 17: 10240(R) (NP-12208)
**MESONS ($\pi^+$)**
lifetime of, mean, 17: 11500 (UCRL-10118(Rev.))
production amplitudes in $\gamma$-$p$ interactions, 17: 11565
production in cosmic-particle reactions on nuclei, 17: 11454
production in meson ($\pi^-$)-xenon interactions at 8.4 Bev/c, 17: 11673
**MESONS ($\pi^0$)**
interactions at high-energy, cross section combinations for, 17: 11529
interactions with protons, meson ($\pi$-$\pi$) amplitudes in low-energy, 17: 11518
production in meson ($K^+$) decay, 17: 11523
**MESONS ($\rho$)**
decay modes of, 17: 11499 (UCRL-10089(Rev.))
prediction of, vector theory, 17: 11496 (TID-17742)
**METAL-FOIL DETECTORS**
properties of, for heavy ions, 17: 11008 (TID-16174)
**METALLIC FILMS**
magnetic properties of superconducting, 17: 11399
sorptive properties for gases in vacuum, research program, 17: 11193(R) (TID-17635)
**METALLURGY**
laboratory for, Riso, 17: 11121
radioisotopes in, in USSR, 17: 10888
review of progress in sintering, 17: 11090 (IS-460)
**METALS**
atomic structure, 17: 10664
bibliography, 17: 11100 (NP-12493)
electric resistivity of, effects of lattice vacancies on, 17: 11231
electron emission from, by helium and hydrogen collisions, secondary, 17: 11397
electron scattering by localized moments in, conduction, 17: 11367
enthalpy, free heat content, and work function of, relations among, 17: 10658
fracture, electron microscopic techniques for studying, 17: 11083 (DMIC-Memo-161)
plastic deformation of polycrystalline, review of technology on, 17: 11196 (UCRL-10152)
positron annihilation in, 17: 11539
properties of refractory, summary of, 17: 11119(T) (JPRS-17322)
radiation effects, 17: 11129
separation by cation exchange, 17: 10733 (IS-466)
weldability of, review of, 17: 11166 (HW-SA-2527)
**METEORITES**
analysis for aluminum-26 and sodium-22, radiometric, 17: 10839
characteristics of Bondoc, 17: 10838
Cosmic-ray-induced argon-37, -39 ratio in recently fallen, 17: 11448

(BNL-6545)
distribution of rare earth in, 17: 10821(R) (GA-2985)
**METEOROLOGY**
factors affecting particle diffusion and transport in atmosphere, 17: 10848(R) (HW-73337(p.1-28))
relation to air pollution control, 17: 10843 (BNL-6538)
**METHACRYLIC ACID, METHYL ESTER**
radiolysis with amines, formation of amine cation radicals in, 17: 10687
**METHANE**
radiation effects on reactions with ammonia, 17: 10704
**METHANE, DIIODO-**
reactions with pyrrole to form pyridine, 17: 10669(T) (NP-tr-942)
**METHANOL**
radiolysis of liquid, effects of cesium, potassium, and rare earth salts on yields in, 17: 10699
**METHYLAMINE**
distillation of, with carbon dioxide, isotope effects in, 17: 10521
preparation of carbon-14-labeled hydrochloride of, 17: 10517 (PAN-336/XIII)
**METRAZOLE**
effects of, on radiation injury in central nervous system in mice, 17: 10263
**MICE**
immunity in irradiated and urethan-treated, role of thymus in recovery of, 17: 10412
infection with mousepox, effects of deuterium oxide on, 17: 10285
plutonium-239 distribution in, autoradiography of injected, 17: 10260
radiation effects on immunity to *Trichinella spiralis* infection in, 17: 10424
radiation effects on mortality in, infected with *Trichinella spiralis*, 17: 10431
radiation effects on glomerular lesions in kidneys in, pathogenesis of whole-body, 17: 10433
radiation effects of fast neutrons, 17: 10358 (BNL-6575)
radiation effects on lymph system of, x, 17: 10406
radiation effects on metaphase/prophase ratio in, 17: 10411
radiation effects on antibody formation, 17: 10255(R) (TID-17648)
radiation effects on central nervous system in, injected with stimulants, 17: 10263
radiation injuries in, effects of dithiocarbamates against, 17: 10428
radiation injuries in, effects of foreign spleen cells on blood and tissue changes in, 17: 10434
radiation injuries in, effects of isologous bone marrow and leukemoid leukocyte injections on, 17: 10283
radiation sickness in, protective effects of Tanderil against, 17: 10472
radioinduced lung tumors, 17: 10476
radiosensitivity of, under mild hypothermia, 17: 10438
toxic effects of inhaled plutonium-239, 17: 10323
toxicity of plutonium in, 17: 10317
**MICROWAVE EQUIPMENT**
development of klystrons, 17: 11798(R) (TID-17221)
electromagnetic wave confinement by plasma waveguides, 17: 11828 (AFCRL-62-63)
electromagnetic wave propagation in cylindrical waveguide containing inhomogeneous plasma, 17: 11843
operation of, analysis of deflecting mode in synchrotron waveguides, 17: 11783 (BNL-6670)
properties of disc-loaded waveguides, 17: 11798(R) (TID-17221)
properties of grid-loaded structures, 17: 11798(R) (TID-17221)
shower development and heating in the waveguide structure by 800-Mev electron beam, 17: 11794 (SLAC-3)
**MICROWAVE SPECTROMETERS**
design and performance of nuclear magnetic resonance, review, 17: 10929
**MICROWAVES**
absorption by plasma, 17: 11836 (RADC-TDR-62-186)
propagation in afterglow plasmas and magnetoplasmas, 17: 11834(R) (NP-12367)
propagation through a plasma in a magnetic field, 17: 11862
**MILK**
analysis for cesium-137 by beta counting, 17: 10551
analysis for iodine-131 by anion exchange, spectrometric, 17: 10554
content of strontium-90, effects of grass contamination, 17: 10352
**MINERALS**
age estimation of, effects of escape of radioactive gases on, 17: 10829
analysis for uranium, fission, 17: 10555
diffusion of argon and helium from, determination of activation energy spectra in, 17: 10830
diffusion of argon in, 17: 10831
**MINNESOTA**
fallout monitoring, 1959, 17: 10352
**MITOSIS**
radiation effects on metaphase/prophase ratio in man and mice, 17: 10411
**MIXER-SETTLERS**
design of high-capacity, general, 17: 10786
**MOLECULAR PROPERTIES**
stability of molecules in the Thomas-Fermi theory, 17: 11419
**MOLECULES**
calibration of labeled, procedures and instrumentation used by CNEA in, 17: 10677 (NP-12235)
quantum statistics of, with internal rotator, 17: 11343
spin couplings of, Heitler-London method of calculation of, 17: 11420
stability of, in Thomas-Fermi theory, 17: 11419
**MOLYBDENUM**
deformation at low and moderate temperatures, 17: 11223
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
fabrication techniques for, control of grain growth by, 17: 11295(R) (AD-277713)
hardness, 17: 11093(R) (NMI-2112)
hardness, 17: 11094(R) (NMI-2113)
heat of vaporization, 17: 10240(R) (NP-12208)
radiation effects, 17: 11129
stress-rupture properties at 2200°C in argon and hydrogen, 17: 11087(R) (GEMP-19A)
superconducting isotope effect in, 17: 11375
**MOLYBDENUM ALLOYS**
preparation and properties, 17: 11224
Fe–Mo, thermal expansion of solid solutions of, anomalies in, 17: 11238
Hf–Mo, hardness, 17: 11094(R) (NMI-2113)
Ir–Mo, superconducting isotope effect in, 17: 11375
Mo–Nb, properties of welded, 17: 11242
Mo–Nb–V–Zr, extrusion of tubing from, optimization studies, 17: 11140(R) (AMC-TR-7-775(VII))
Mo–Os, hardness, 17: 11094(R) (NMI-2113)
Mo–Re, hardness, 17: 11094(R) (NMI-2113)
Mo–Tc, crystalline-phase and superconducting properties of, 17: 11363
Mo–Tc, phase studies on, 17: 11220
Mo–Ti, fabrication for grain growth control, 17: 11295(R) (AD-277713)
Mo–Ti, mechanical properties of, effects of potassium vapor at 2000°F on, 17: 12036(R) (SY-5396-R3)
Mo–U, fabrication and testing, 17: 11096(R) (NMI-7256)
Mo–Zr, beta phase stabilization in, 17: 11213
**MOLYBDENUM BROMIDES**
preparation and properties, 17: 10590 (IS-487)
**MOLYBDENUM CARBIDES**
hot pressing of powders, 17: 11170(T) (AEC-tr-5604)
melting point, 17: 11201(T) (AEC-tr-5598)
production of graphite-coated particles of, by fluidized bed process, 17: 11174
**MOLYBDENUM ISOTOPES Mo-98**
neutron resonance integral, 17: 11979(R) (DP-805)
**MOLYBDENUM ISOTOPES Mo-99**
determination in radiation source mixture with lanthanum-140, from decay data, 17: 10547
**MOLYBDENUM SYSTEMS**
Cr–Mo–$UO_2$, radiation effects on stainless steel-clad, 17: 11254 (BMI-1608)
**MONAZITES**
decomposition using pyrophosphoric acid, 17: 10556
**MONEL**
brazing and welding of, criteria for, 17: 11163 (DMIC-181)
**MONKEYS**
radiation sickness of, effects of, on maturation and proliferation of bone marrow in, 17: 10495

**MONOCHROMATORS**
development of electron, using modified Wien filter, 17: 10939
**MONOSACCHARIDES**
mass spectra of methyl esters of, 17: 10557
**MONTE CARLO METHOD**
use for calculating energy-dependent multiple neutron scattering in thin plates, 17: 11595 (TID-15571)
use in critical-size calculations for neutron systems, 17: 11462 (UCRL-6707)
**MOSQUITOES**
labeling of larvae and adults with phosphorus-32, 17: 10423
radioinduced mutations in adult male, 17: 10385
**MÖSSBAUER EFFECT**
phonon annihilation and creation effects on, 17: 11658
**MOUTH**
gingival ulceration induced by radium-226, radium-228, or thorium-228, 17: 10296(R) (COO-226(p.35-49))
**MULTIPLICATION FACTOR**
eigenvalue matrix solution to N-component neutron interaction problems in arrays of neutron emitters, 17: 11458 (HW-75887)
fluctuations in boiling-water reactors, minimization of, 17: 12008
stability of, in reactors with negative-feedback control, 17: 12004
**MUSCLES**
radiation effects on prepyriform electrical activity in, in rats, whole-body, 17: 10373
zinc distribution and turnover in, in rats, tracer study, 17: 10275
**MUTATIONS**
in *D. melanogaster* males, effects of carbon-14- and tritium-labeled DNA precursors on, 17: 10401
radiation effects on, in *Neurospora crassa* exposed to nitrogen mustard, 17: 10455
radioinduced in *Escherichia coli*, 17: 10364(R) (TID-17690)
radioinduced in *Medicago sativa L.*, cytogenetics of, 17: 10398
radioinduced in *Medicago sativa L.*, morphology of, 17: 10399

# N

**NAGASAKI**
effects of atomic explosion at, on thyroid gland function in children exposed *in utero*, 17: 10371
**NAPHTHALENE**
effects on photoreduction of benzophenone, 17: 10680(R) (TID-17584)
**NAVAL VESSELS**
nuclear propulsion of, review of advantages and disadvantages, 17: 10252
**NECK**
radiation effects on esophagitis, therapeutic, 17: 10269
**NEODYMIUM**
determination in aluminum as trace impurity, activation, 17: 10546
excited state lifetime in calcium tungstate, measurement of, 17: 10651
reactions with ammonium, potassium, and sodium salts, precipitation, 17: 10621
**NEODYMIUM ALLOYS**
Nd–Y, phase studies, 17: 11186 (DRI-2080)
**NEODYMIUM ARSENIDES**
thermoelectric properties, 17: 11296 (AD-278352)
**NEODYMIUM CHLORIDES**
paramagnetic spin-lattice relaxation of hydrated, at 1.1 to 4.2°K, 17: 10652
**NEODYMIUM ETHYL SULFATES**
paramagnetic resonance in, magneto-optical Faraday effect in, 17: 10617
quadrupole hyperfine structure of europium isotopes in, 17: 11647 (UCRL-10202)
spin level saturation in, magneto-optical Faraday effect measurement of, 17: 10617
**NEODYMIUM ISOTOPES Nd-144**
carbon nucleus reactions with, measurements of various parameters of, 17: 11645 (UCRL-10099)
**NEODYMIUM ISOTOPES Nd-146**
carbon nucleus reactions with, measurements of various parameters of, 17: 11645 (UCRL-10099)
**NEODYMIUM OXIDES**
separation from europium, polarographic, 17: 10572
**NEODYMIUM SELENIDES**
thermoelectric properties, 17: 11296 (AD-278352)
NdSe–YbSe, thermoelectric properties, 17: 11296 (AD-278352)
**NEODYMIUM TELLURIDES**
thermoelectric properties, 17: 11296 (AD-278352)
**NEODYMIUM VANADATES**
structure of, x ray diffraction analysis of, 17: 10663
**NEON**
microwave discharge afterglow in, electron density in, 17: 11384
neutron absorption and scattering cross sections for natural, thermal, 17: 11620 (EANDC(E)-10,U)
reactions with hot tungsten surface at 1710 to 2500°K, energy exchange in, 17: 10609 (UCRL-10504)
**NEON IONS**
energy levels of, 20-parameter eigenfunctions and energies of $2^4S$ states of, 17: 11751
**NEON ISOTOPES**
separation by thermal diffusion, 17: 10240(R) (NP-12208)
**NEON ISOTOPES Ne-20**
electronic charge distribution at high energy, 17: 11388
**NEON ISOTOPES Ne-21**
energy level transitions in, 17: 11660
**NEON ISOTOPES Ne-22**
transfer reactions with thorium, 17: 11473 (JINR-P-1071)
**NEON SYSTEMS**
Hg–Ne, electron density and temperature in plasma of, 17: 11883
**NEPTUNIUM**
determination in aluminum as trace impurity, activation, 17: 10546
determination of, spectrophotometric, 17: 10533 (HW-SA-2657)
transfer from plasma to milk in sheep, tracer study, 17: 10326
**NEPTUNIUM CHLORIDES**
reactions with aluminum chlorides, complex formation in, 17: 10586 (HW-SA-2597)
**NEPTUNIUM COMPLEXES**
with chloride, anion exchange and nonaqueous studies, 17: 10585 (HW-SA-2596)
**NEPTUNIUM(V) IONS**
reduction, mechanism, 17: 10596 (TID-15793)
**NERVE CELLS**
radiation effects on, in rats, 17: 10461
radiation effects on, in rats, 17: 10466
**NERVES**
radiation effects on electrical excitation of isolated, 17: 10417
sensitivity to ultraviolet light, 17: 10310(R) (TID-17789)
**NERVOUS SYSTEM**
radiation effects on ribonucleic acid metabolism, 17: 10356 (BNL-6546)
radiation effects on central, in mice injected with stimulants, 17: 10263
**NEUTRINOS**
currents of, classification of, 17: 11479 (LNF-62/98)
emission of pairs of, by stellar plasma, 17: 11446
existence of two, postulation for, 17: 11478 (LNF-62/97)
experiments with high energy, interpretation of, 17: 11471 (JINR-E-1120)
interactions of, cross sections for elastic and inelastic, 17: 11478 (LNF-62/97)
interactions with nucleons, cross sections for, 17: 11563
production in meson($\pi$) decay, 17: 11471 (JINR-E-1120)
**NEUTRON BEAMS**
production of thermal, using split reactor cores, 17: 12030
properties of cyclotron, 17: 11627 (TID-15088)
**NEUTRON CROSS SECTIONS**
bibliography on Russian work, 17: 11613 (BNL-768)
**NEUTRON DECAY**
radiative corrections in, 17: 11469 (JINR-E-1100)
**NEUTRON MONOCHROMATORS**
design of rotating-disk, 17: 10937
pulse forms and transmission functions for two-rotor, 17: 10938
**NEUTRON PHOTOGRAPHY**
comparison with other radiographic methods, 17: 10814 (ANL-FGF-335)
image formation in, efficiency of thermal neutrons for, 17: 10880 (ARF-1164-27)
testing of polaroid camera for, 17: 10999 (ANL-FGF-340)
**NEUTRON SCATTERING CROSS SECTIONS**

bibliography on inelastic, 17: 11587 (AE-88)
**NEUTRON SHIELDING**
neutron angular distribution and capture radiation in slabs of borated polyethylene, lead, and steel, 17: 11900 (NARF-62-16T)
**NEUTRON SOURCES**
development, 17: 11936(R) (ANL-6672)
development for industrial radiography, 17: 10880 (ARF-1164-27)
neutron emission measurement, 17: 10849(R) (HW-73337(p.29-76))
**NEUTRON SPECTRA**
measurement by time-of-flight, 17: 10240(R) (NP-12208)
measurement in reactors, 17: 11594 (SCTM-205-62(53))
**NEUTRON SPECTROMETERS**
design, calibration, and use of fast delayed coincidence, 17: 11627 (TID-15088)
resolution of time-of-flight, 17: 11779 (BNL-767(p.278-87))
**NEUTRON SPECTROSCOPY**
design of instruments for recoil proton collimation in, 17: 10889 (AD-252467)
improvements in, 17: 11638(R) (TID-17720(p.38-61))
time-of-flight, delay system for use in, 17: 11036
**NEUTRONS**
absorption in materials having grain structures, resonance, 17: 11604
angular distributions from deuteron reactions (d,n) in fluorine-19, 17: 11636(R) (TID-17720(p.8-14))
angular distributions at the surface of cadmium rods at the center of a reactor, 17: 11303(R) (HW-75228)
attenuation by slabs of lead, borated polyethylene, and steel, 17: 11900 (NARF-62-16T)
capture by boron in PWR-2 fuel assembly, 17: 11995 (WAPD-T-1371(Rev.))
currents in thin regions of asymmetric configuration, 17: 11596 (TID-15752)
detection and measurement of, design of detectors for use in power reactors, 17: 10986
detection and measurement of, design of fission chamber for operation at very high temperatures, 17: 10987
detection and measurement using a proton-recoil proportional counter, 17: 11002 (CNEN-158)
detection and measurement of, performance of gas scintillation counter for, 17: 11005 (IKF-5)
detection in drill holes, probe design for, 17: 10836
diffusion equation for, with variable coefficients, solution by a power series method, 17: 11590 (NP-12368)
diffusion in limited reactor regions, boundary-control method for, 17: 11598 (WAPD-T-1457)
distribution in critical system, Monte Carlo calculations of, 17: 11462 (UCRL-6707)
dosimetry of, design of isodose detector system for, 17: 11034
exchange of, in high-energy ion-ion reactions, 17: 11492 (TID-16044)
flux calculations for an exponential pile, two-group, 17: 11303(R) (HW-75228)
flux distribution of, measurement by foil activation, 17: 11608
flux measurements by gold foil activation, self-shielding coefficients for, 17: 11609
form factors of, from deuteron-electron elastic scattering, 17: 11505
genetic effects on maize under different physiological conditions, 17: 10380
interactions with protons, quantum mechanical relations for, 17: 11932
moderation of, parameters for, 17: 11605
photoproduction on nitrogen-14 and oxygen-18 at 30.5 Mev, 17: 11756
polarization of, by scattering, compound nuclear and direct contributions to, 17: 11752
polarization of, in reactions d(γ,n), 17: 11805(R) (TID-17728)
production in deuterium plasma, 17: 11866
production in gamma reactions (γ,n) with carbon-12 and oxygen-16 at 30.5 Mev, 17: 11755
production in proton reactions with rhodium at 5 to 12 Mev, 17: 11631 (TID-16049)
reactions (n,α) in lithium-6, electron microscopic observation of, 17: 11615 (BNL-6082)
reactions (n,α) and (n,p) with nuclei at 14.5 Mev, cross-section calculations by statistical theory for, 17: 11754
reactions (n,2n), bibliography on, 17: 11587 (AE-88)
reactions (n,2n) with lithium-6 and -7 at 10.2 and 14.1 Mev, cross sections for, 17: 11722
reactions with non-fissile materials, production of thermal energy in, 17: 11619 (CEA-2172)
reactions with nuclei, mechanisms of, 17: 11708
reactions with nuclei at low energies, theory of, 17: 11740
reactions with plutonium-239 at 0.061 to 6.5 kev, capture-to-fission ratios in, 17: 11936(R) (ANL-6672)
resonance integrals in uranium metal and oxide, 17: 11667
resonance integrals in uranium metal and oxide, 17: 11668
rethermalization of, in heavy water coolants, 17: 11962 (TID-17574)
scattering by crystals, effects of four-phonon interactions on energy distributions in, 17: 11510
scattering by impurity centers of crystals, theory of magnetic, 17: 11511
scattering by lattice defects in ferromagnetic crystals, 17: 11610
scattering by liquids, inelastic, 17: 11414
scattering by nuclei, inelastic, 17: 11708
scattering in thin plates, Monte Carlo calculations of elastic energy-dependent multiple, 17: 11595 (TID-15571)
scattering in water, comparison of Nelkin's kernel with experiment, 17: 11303(R) (HW-75228)
scattering of, computer code for Hauser Feshbach calculations on, 17: 11591 (NP-12370)
scattering of, quasi-classical approximation in, 17: 11606
slowing down approximations in transport theory of, 17: 11592 (NP-12480)
slowing-down of, renewal theory for, 17: 11603
spatial variations and spectra of, in uranium–water lattices, 17: 11940 (CRRP-895)
spectra from deuteron-triton interactions at 5 to 12 Mev, 17: 11526
stopping in peat and water, 17: 10559
streaming in water-$d_x$-filled pipes, 17: 11588 (AE-98)
temperature of, use of lutetium in measurement of, 17: 11586 (AAEC/TM-164)
theory of thermalization, utilization, and resonance absorption, 17: 11975
thermalization experiments, review, 17: 12011
transport in finite moderators, time-dependent solutions for, 17: 11597 (TID-16085)
transport of, integral equation of energy-dependent, 17: 11601
transport of monoenergetic, in non-moderating assemblies, 17: 11598 (TID-16304)
**NICKEL**
corrosion by carbon tetrachloride–chlorine/oxygen, 17: 10246(R) (ORNL-TM-403)
determination in alloys, 17: 10539 (TID-16296)
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
deuteron scattering at 3 to 30 Mev, optical model analysis of, 17: 11676
dissolution rate in liquid aluminum, 17: 10577 (ANL-FGF-292)
heat of vaporization, 17: 10240(R) (NP-12208)
neutron critical scattering in, 17: 11222
radiation effects, 17: 11129
separation from metal ionic mixtures, electrochromatographic, 17: 10753
separation from trivalent rare earths by cation exchange, 17: 10734 (IS-508)
**NICKEL ALLOYS**
brazing of, criteria for, 17: 11163 (DMIC-181)
corrosion studies of, technical progress review, 17: 11129
phase studies, 17: 11204(T,R) (EURAEC-444)
welding of, criteria for fusion and resistance, 17: 11163 (DMIC-181)
Al–Mn–Ni, composition of X phase in, 17: 11249
Cu–Ni, oxidation of, selective, 17: 11135(T,R) (EURAEC-483)
Fe–Ni, allotropic transformation in, 17: 10240(R) (NP-12208)
Fe–Ni, anisotropic energy of electron irradiated, 17: 11274
Mn–Ni, conduction electron momentum in, electron–positron annihilation studies, 17: 11275
Ni–Zr, phase studies, 17: 11204(T,R) (EURAEC-444)
**NICKEL CRYSTALS**
diffusion of bismuth (liquid) into boundaries of oriented, 17: 11241
stress-strain curve for, magnetic measurement of, 17: 11234

**NICKEL ELECTRODES**
thermionic emission in gases, 17: 11435
**NICKEL FILMS**
thickness uniformity of commercial, 17: 11104 (TID-16252)
**NICKEL ISOTOPES Ni-57**
nuclear state alignment of, 17: 11703
**NICKEL ISOTOPES Ni-58**
deuteron elastic scattering cross sections at 12.8 Mev, 17: 11688
electron inelastic scattering by, partial-wave analysis of, 17: 11710
proton reactions (p,p' γ), angular correlation symmetries in, 17: 11684
proton reactions (p,pn) and (p,2p), 17: 11703
**NICKEL ISOTOPES Ni-59**
electron capture decay of, virtual, 17: 11709
gamma spectra, 17: 11709
**NICKEL ISOTOPES Ni-60**
deuteron elastic scattering cross sections at 12.8 Mev, 17: 11688
electron inelastic scattering by, partial-wave analysis of, 17: 11710
**NICKEL ISOTOPES Ni-64**
proton scattering at 9.6 and 11.7 Mev by, differential cross sections for, 17: 11643 (UCRL-6930)
**NICKEL NITRATES**
salting-out properties in uranyl nitrate extraction from aqueous solutions, 17: 10770
**NICKEL STEEL**
mechanical properties, 17: 11099(R) (NP-12475)
Cr–Ni, effects of niobium and zirconium on, 17: 11210
**NIMONIC-80**
brazing and welding of, criteria for, 17: 11163 (DMIC-181)
**NIMONIC-90**
brazing and welding of, criteria for, 17: 11163 (DMIC-181)
**NIOBIUM**
alloying effects on chromium-nickel steel, 17: 11210
alloying effects on copper-zirconium alloys, 17: 11225
corrosion studies of, technical progress review, 17: 11129
deformation at low and moderate temperatures, 17: 11223
deposition on ceramic particles, 17: 11116(T) (EURAEC-487)
elastic-wave attenuation in superconducting, at 5 to 30 Mc, 17: 11400
hardness, 17: 11093(R) (NMI-2112)
nuclear quadrupole resonance, 17: 10592 (IS-520)
refining of, use of iodide for, 17: 10635
separation from fuel reprocessing solutions, 17: 10519(T,R) (EURAEC-460)
separation from irradiated molybdenum using di-isobutyl ketone, 17: 10714
sorptive properties for nitrogen and oxygen in vacuum, research program, 17: 10602(R) (TID-16820)
spectra of, atomic absorption, 17: 10549
welding of, effects of, on properties, 17: 11242
**NIOBIUM ALLOYS**
welding of commercial, effects of, on properties, 17: 11243
Cr–Nb, corrosion by liquid sodium, 17: 11935(R) (ANL-6658)
Cr–Nb–Ti, phase studies at 600, 800, and 1000°C, 17: 11212
Cr–Nb–Zr, phase studies, 17: 11108(T,R) (EURAEC-307)
Hf–Nb, properties of welded, 17: 11242
Mo–Nb, properties of welded, 17: 11242
Mo–Nb–V–Zr, extrusion of tubing from, optimization studies, 17: 11140(R) (AMC-TR-7-775(VII))
Nb–Re, extrusion, 17: 11093(R) (NMI-2112)
Nb–Re, hardness, 17: 11093(R) (NMI-2112)
Nb–Sn, use in magnetic shielding for energetic protons, 17: 11899 (N62-10900(Pt.IV))
Nb–Tc, phase studies on, 17: 11220
Nb–Ti, properties of welded, 17: 11242
Nb–V, properties of welded, 17: 11242
Nb–V–Zr, phase studies, 17: 11108(T,R) (EURAEC-307)
Nb–W, properties of welded, 17: 11242
Nb–Zr, attenuation of 5- to 30-Mc elastic waves in superconducting, 17: 11400
Nb–Zr, beta phase stabilization in, 17: 11213
Nb–Zr, corrosion by liquid sodium, 17: 11935(R) (ANL-6658)
Nb–Zr, fabrication of, for mercury corrosion loop, 17: 11131 (AGC-0584-04-5)
Nb–Zr, fatigue behavior in potassium at 800°F, 17: 12036(R) (SY-5396-R3)
Nb–Zr, mechanical properties at −300 to 1200°F, 17: 11075(R) (AD-278043)
Nb–Zr, mechanical properties, 17: 11108(T,R) (EURAEC-307)
Nb–Zr, properties of welded, 17: 11242
**NIOBIUM BORIDES**
bibliography on preparation and properties of, 17: 10579 (ASD-TDR-62-873)
**NIOBIUM BROMIDES**
reactions with pyridine, 17: 10500 (IS-385)
**NIOBIUM CARBIDES**
formation in niobium steel, 17: 11209
melting point, 17: 11201(T) (AEC-tr-5598)
superconductivity of, negative results, 17: 11391
NbC–TaC, melting point, 17: 11201(T) (AEC-tr-5598)
NbC–TaC–ZrC, melting point, 17: 11201(T) (AEC-tr-5598)
NbC–$W_2C$, melting point, 17: 11201(T) (AEC-tr-5598)
NbC–ZrC, melting point, 17: 11201(T) (AEC-tr-5598)
**NIOBIUM CHLORIDES**
reactions with pyridine, 17: 10500 (IS-385)
**NIOBIUM COATINGS**
deposition on uraniferous ceramic particles, 17: 11112(T,R) (EURAEC-409)
**NIOBIUM COMPLEXES**
with EDTA, polarography of, 17: 10544
**NIOBIUM FLUORIDES**
identification in hydrofluoric acid solutions, 17: 10511(R) (ORNL-3320(p.56-82))
**NIOBIUM HYDRIDES**
NbH–TiH, crystal structure and hydrogen sorption in, 17: 11237
**NIOBIUM IODIDES**
reactions with pyridine, 17: 10500 (IS-385)
**NIOBIUM ISOTOPES Nb-92**
preparation of high specific activity, 17: 10714
**NIOBIUM ISOTOPES Nb-95**
separation of, from nitric acid, efficiency of AMSCO-TBP in, 17: 10739(R) (ORNL-TM-27)
**NIOBIUM ISOTOPES Nb-99**
decay scheme, 17: 10506(R) (ORNL-3320(p.1-15))
**NIOBIUM OXIDES**
reduction by carbon monoxide at 800 to 1050°C, 17: 10661
solid-phase reactions of, at high pressures, 17: 10503 (NP-12359)
**NIOBIUM STEEL**
carbide formation in, 17: 11209
**NIOBIUM SYSTEMS**
C–Nb–W–Zr, extrusion of tubing from, optimization studies, 17: 11140(R) (AMC-TR-7-775(VII))
Nb–O, mechanical properties of, 17: 11219
Nb–$UO_2$, radiation effects on niobium-clad, 17: 11254 (BMI-1608)
**NITRATES**
analysis of liquid, for water, 17: 10518(R) (TID-17823)
anodic depolarization of fused, in bromide, chloride, and cyanide, 17: 10518(R) (TID-17823)
radiolysis of aqueous, 17: 10509(R) (ORNL-3320(p.30-46))
**NITRIC ACID**
chemical effects on sodium molybdates, 17: 10611(T) (UCRL-Trans-894(L))
reactions with uranium carbide, 17: 10246(R) (ORNL-TM-403)
separation from thorium nitrate by anion exchange, prediction of loss curves in, 17: 10763
solvent partition in TBP–uranyl nitrate systems, 17: 10511(R) (ORNL-3320(p.56-82))
solvent properties for uranium dioxide pellets, effects of nitrates on dissolution rate, 17: 10246(R) (ORNL-TM-403)
solvent properties for rare earths, 17: 10764
$Al(NO_3)_3$–$HNO_3$–$UO_2(NO_3)_2$–$H_2O$, phase diagrams, 17: 10616
Cr–$HBF_4$–HF–$HNO_3$–Zr, solvent properties for uranium–zirconium alloy, 17: 10246(R) (ORNL-TM-403)
HF–$HNO_3$, corrosive effects on stainless steel, 17: 10246(R) (ORNL-TM-403)
$HNO_3$–$UO_2(NO_3)_2$–$H_2O$, phase equilibrium in, 17: 10615

**NITRILES**
protective effects against radiation injur es in mice, reaction mechanisms, 17: 10482(R) (NP-12251(p.47-66))
**NITRITES**
radiolysis of potassium bromide dispersions of, 17: 10509(R) (ORNL-3320(p.30-46))
**NITROGEN**
exchange between nitrates and nitrites, 17: 10508(R) (ORNL-3320 (p.22-9))
hyperfine structure in atomic, pressure shifts of, 17: 11387
ionization of, effect of oxygen and water vapor on, 17: 11047
meson ($\pi^-$) capture by, single charged particle emission in, 17: 11679
nuclear quadrupole resonance, 17: 10592 (IS-520)
radiation effects on metabolism of acid soluble, in barley seedlings, 17: 10456
radiation effects on liquid, 17: 11264(R) (NP-12388)
reactions with hot tungsten surface at 1710 to 2500°K, energy exchange in, 17: 10609 (UCRL-10504)
sorption by niobium in vacuum, research program, 17: 10602(R) (TID-16820)
**NITROGEN FLUORIDES**
stability of, radiation and thermal effects on, 17: 10516 (ORNL-TM-475)
**NITROGEN ISOTOPES**
equilibria in systems of carbon dioxide with primary and secondary amines, 17: 10521
**NITROGEN ISOTOPES N-14**
deuteron reactions (d,n), neutron polarization in, 17: 11633(R) (TID-17534)
deuteron scattering cross sections at 2.1 Mev, 17: 11633(R) (TID-17534)
electronic charge distribution at high energy, 17: 11388
energy levels at 6.44, 7.03, and 9.17 Mev, 17: 11714
excited states in, from deuteron reactions in carbon-12, 17: 11623 (NP-12496)
gamma reactions (γ,n) at 30.5 Mev, neutron spectra from, 17: 11756
helium nucleus reactions (helium-3,α), 17: 11721
neutron reactions (n,d) at 14.1 Mev, angular distributions of, 17: 11716
proton inelastic scattering by, dipole-resonance effects on, 17: 11734
**NITROGEN ISOTOPES N-15**
nuclear state alignment of, 17: 11703
**NITROGEN MUSTARDS**
radiation effects on genetics of *Neurospora crassa* exposed to, visible, 17: 10455
**NITROGEN SYSTEMS**
$N_2$–$O_2$, radiolysis of, 17: 10509(R) (ORNL-3320(p.30-46))
**NOISE**
in instrumentation systems, 17: 10915 (TID-17749)
measurement of, computer analysis of performance of linear and square-law detectors for, 17: 10916 (TID-17788)
of gas discharges, 17: 11829 (ASD-TR-61-179(Vol.I))
**NRL RESEARCH REACTOR**
neutron spectra in modified, slow, 17: 12030
**NUCLEAR BATTERIES**
bibliography, 17: 11322 (NP-12429)
**NUCLEAR EMULSIONS**
development of high-space-resolution, 17: 11333 (TID-17640)
grain densities of highly ionized particle tracks in, photomicrographic techniques for measuring, 17: 10919 (USNRDL-TR-591)
preparation of uranyl acetate-loaded, 17: 11039
radiation effects on exposed, developed, and dried gelatin of, 17: 10703
**NUCLEAR ENGINEERING**
conference on education, 17: 10247 (TID-7638)
heat transfer, review, 17: 12012
**NUCLEAR ISOMERS**
use of, in production of polarized particle beams, 17: 11640(R) (TID-17720(p.79-89))
**NUCLEAR MAGNETIC RESONANCE**
analysis of liquids and solids by, 17: 10946
modes in magnetic materials, theory of, 17: 11379
**NUCLEAR MODELS**
distributions from reactions in statistical, 17: 11675
nucleon momentum distribution from quasi-deuteron, 17: 11695
parameters of generalized diffraction, at 660 Mev, 17: 11307 (JINR-P-1009)
**NUCLEAR MODELS (COLLECTIVE)**
differential cross sections in, 17: 11699
parameters for even-even deformed nuclei in, 17: 11732
**NUCLEAR MODELS (OPTICAL)**
theory of low-energy nuclear reactions, 17: 11740
**NUCLEAR MODELS (SHELL)**
collective motion in even-even deformed nuclei in, 17: 11732
energy level calculations, 17: 11739
meson ($\pi^-$) capture in studies on, 17: 11687
**NUCLEAR PARTICLES**
production of polarized beams of, 17: 11640(R) (TID-17720(p.79-89))
**NUCLEAR PHYSICS**
research in high-energy, 17: 11331(R) (TID-17023)
solution of kinetic equations in, application of the stationary phase method in, 17: 11308 (JINR-P-1113)
**NUCLEAR POWER**
cost analysis of kilowatt hour, 17: 10250
economics and potential of uranium use for, 17: 11968
economics and prospects of, in EURATOM countries, 17: 10251
**NUCLEAR POWER PLANTS**
corrosion problems, review, 17: 11133 (TID-16561)
cost evaluation, use of guide in, 17: 12010
design of magnetohydrodynamic, 17: 12002
design optimization of organic-cooled, 17: 11979(R) (DP-805)
development and selection of type of, for Yugoslavia, 17: 11976
equipment for Yugoslavia, possibility of domestic manufacture of, 17: 11976
**NUCLEAR REACTIONS**
cosmic-particle, mesons ($\pi^0$) from, 17: 11454
multinucleon transfer between complex nuclei, 17: 11737
photo-, excitation by protons, 17: 11734
photo-, tensor effects on sum rule for, 17: 11733
polarization effects in, 17: 11662
research on, at Johns Hopkins Univ., 17: 11635(R) (TID-17720)
theory for pickup (p,d), 17: 11492 (TID-16044)
theory of direct interaction, 17: 11669
theory of low-energy, 17: 11740
**NUCLEAR SPIN**
effects on Regge pole position, 17: 11485 (NP-12478)
**NUCLEAR STRUCTURE**
energy level densities in, measurement by inelastic neutron scattering, 17: 11708
second-order effects of nuclear magnetic fields on, 17: 11617 (BNL-6205)
**NUCLEAR THEORY**
delta-function potential in a box, 17: 11910
meson (K) and ($\pi$) clouds around antibaryons and baryons, symmetry properties of, 17: 11547
nucleon magnetic properties in, models for, 17: 11558
nucleon structure in, 3-meson ($\pi$) effects on isoscalar, 17: 11559
photonuclear reaction sum rules in, tensor effects on, 17: 11733
quasi-deuteron model and the internal momentum distribution of nucleons in carbon-12, 17: 11695
relation of bispinor and spinor theory in Riemann space, 17: 11931
simulation of the hard core by a velocity dependence, 17: 11921
superfluid properties of nuclei in, 17: 11735
**NUCLEI**
acceleration in Brookhaven AGS, experiments with, 17: 11784 (BNL-6673)
collective motion in even-even deformed, 17: 11732
collective motion in, coefficients of SU, group for, 17: 11928
collective vibrations in A ≈ 30, 17: 11661
cosmic-particle reactions on, mesons ($\pi^0$) from, 17: 11454
coupling schemes and effective interactions in, 17: 11739
deuteron scattering by light, 17: 10240(R) (NP-12208)
deuteron stripping in Coulomb field of heavy, classical description of, 17: 11630 (TID-15924)
electromagnetic transitions in deformed odd-odd, 17: 11654
electron scattering by, partial-wave analysis of, 17: 11710
energy level densities in, measurement by inelastic neutron scattering, 17: 11708

energy levels of deformed even, perturbation corrections to, 17: 11665
gamma absorption and emission in crystals, phonon effects on, 17: 11658
gamma oscillations in deformed, potential energy of, 17: 11748
gamma reactions on, tensor effects on nucleon production in, 17: 11733
mesons ($\pi^-$) capture, two-hole excitation studies using, 17: 11687
model for odd-mass 1d-2s shell, single particle Nilsson, 17: 11660
neutron reactions (n,$\alpha$) and (n,p) at 14.5 Mev, cross-section calculations by statistical theory for, 17: 11754
neutron scattering by, compound and direct contributions to polarization in, 17: 11752
nucleon binding energy and distribution in, 17: 11736
nucleon exchange reactions between complex, 17: 11737
nucleon inelastic scattering by, amplitudes in, 17: 11731
nucleon scattering on, Green potential for, 17: 11527
oscillator-strengths sum for, effects of hard core on, 17: 11753
particle interactions with delta-function potential, 17: 11910
particle model of scattering from collective states of, 17: 11699
proton reactions at 26.7 Bev, meson production in, 17: 11611 (AD-277387)
proton reactions (p,p'$\gamma$), angular correlation symmetries in, 17: 11684
quadrupole vibration in spherical, high phonon states of, 17: 11685
scattering of spin-0 and spin-½, phase shifts for, 17: 11570
shell structure of, from resonance peaks in (p,n) reactions, 17: 11681
superfluid properties of, 17: 11735
transition probabilities from first $2^+$ states of even-even, 17: 11674

**NUCLEONS**
annihilation on antibaryons, distributions from, 17: 11547
electromagnetic structure of, 3-meson ($\pi$) effects on isoscalar, 17: 11559
emission from nuclei in mesons ($\pi^-$) capture, 17: 11687
exchange reactions between complex nuclei, 17: 11737
interactions at high energy, experimental and theoretical data on elastic, 17: 11507
interactions in nuclei, effective, 17: 11739
interactions with mesons, effects of Regge poles on, 17: 11466 (CERN-62-33)
interactions with mesons($\pi$), differential cross sections for meson($\pi$) production in, 17: 11476 (JINR-P-1111)
interactions with nucleons, vector mesons in, 17: 11491 (TID-15930)
interactions with mesons(K) at high energy, total cross sections and Regge poles for, 17: 11493 (TID-16216)
interactions with nucleons at high energy, cross sections for, 17: 11493 (TID-16216)
interactions with mesons (K), and meson ($Y\bar{Y}$) scattering amplitude in, 17: 11514
interactions with nucleons, single meson ($\pi$) production in peripheral, 17: 11515
interactions with nucleons, Green potential for, 17: 11527
interactions with mesons ($\pi$), two-pion exchange terms in, for states T = 0 and T = 1, 17: 11544
interactions with mesons ($\pi$), Regge poles in, 17: 11546
interactions with nucleons, theory of, 17: 11568
interactions with mesons ($\pi$), Riemann-Cauchy relations in theory of, 17: 11571
interactions with mesons ($\pi$), effect of meson ($\pi$-$\pi$) resonance in, 17: 11578
interactions with photons, and mesons by, radiation damping in, 17: 11916
interactions with neutrinos and antineutrinos, cross sections for, 17: 11563
magnetic properties of, models for, 17: 11558
model for baryon-isobar excited states, 17: 11557
momentum distribution in carbon-12, 17: 11695
nuclear binding energies of, 17: 11736
production by 24-Bev proton beam incident on heavy concrete, 17: 11489 (ORNL-3367)
scattering amplitude of nucleon interactions, analysis of coupling constant and spectral functions in, 17: 11472 (JINR-P-1046)
scattering by nuclei, amplitudes in inelastic, 17: 11731
scattering of, strip approximation to Mandelstam representation of, 17: 11498 (UCRL-10028)
three-body correlations and charge form factors, 17: 11583

**NUCLEOTIDES, PYRIDINE TRIPHOSPHATE**
radiation effects on, in chloroplasts, 17: 10458

# O

**OATS**
radiation effects on diploid and hexaploid species of *Avena*, thermal neutron and x-ray, 17: 10457

**OCEANOGRAPHY**
bibliography on, of Santa Barbara channel area, 17: 10826 (TID-17722)

**OCTYLAMINE**
solvent properties for uranyl sulfate, effects of benzene, carbon tetrachloride, and chloroform on, 17: 10756

**ORES**
analysis of, for lead by gamma or x ray absorption, 17: 10564

**ORGANIC COMPOUNDS**
analysis by mass spectrography, 17: 10943

**ORGANIC COOLED REACTORS**
review of status, 17: 12018

**ORGANIC MODERATED REACTOR EXPERIMENT**
fuel element cleaning by ultrasonics, research program, 17: 11954(R) (NYO-10284)

**ORGANISMS**
radiation effects on fumarase activity in *Tetrahymena pyriformis GL* during cell division, 17: 10409

**ORGANS**
culture of embryonic, 17: 10407
plutonium-239 distribution in mouse, autoradiography of injected, 17: 10260
radioactivity of, after administration of yttrium fluorides, phosphates, and silicates, 17: 10443

**OSCILLOGRAPHS**
circuit for self-biasing of high repetition rate blocking, 17: 10906 (TID-15312)

**OSMIUM**
atomic radiative transition probabilities, 17: 11373

**OSMIUM ALLOYS**
Mo–Os, hardness, 17: 11094(R) (NMI-2113)

**OSMIUM ISOTOPES**
spectra of, 17: 11744

**OXALIC ACID**
properties as radiation dosimeter, 17: 11030

**OXAZOLES, 2,5-DIARYL-**
luminescence and scintillation properties of derivatives of, in polystyrene, 17: 11227(T)

**OXETANES**
radio-polymerization in solid state, 17: 10694

**OXIDATION**
effects on iodine-131 solutions, 17: 10682
mechanisms in anodic, 17: 11138

**OXIDE FILMS**
formation by anodic oxidation, mechanisms for, 17: 11138

**OXIDES**
vaporization of sub-, thermodynamics of, 17: 10645

**OXYGEN**
analysis of, by delayed neutron emission from nitrogen-17, 17: 10534 (IA-784)
diffusion in zirconium, 17: 11129
effects on radiosensitivity of *Pseudomonas aeruginosa*, 17: 10419
exchange between carbon dioxide and dimethyl carbamic acid, 17: 10508(R) (ORNL-3320(p.22-9))
ionization effects in nitrogen-filled chambers, 17: 11047
luminescence quenching effects of, on irradiated sodium chloride dissolved in water, 17: 10612
meson ($\pi^-$) capture by, single charged particle emission in, 17: 11679
photoionization of, cross sections for, 17: 10681(R) (TID-17743)
reactions with carbon monoxides, mechanisms of, 17: 10240(R) (NP-12208)
reduction on film-covered zirconium, production of hydrogen peroxide in, 17: 10623
sorption by niobium in vacuum, research program, 17: 10602(R) (TID-16820)
thermoelectric effects on nickel and platinum, 17: 11435

**OXYGEN IONS**
energy levels of, 20-parameter eigenfunctions and energies of $2^3S$ states of, 17: 11751

**OXYGEN ISOTOPES**
equilibria in systems of carbon dioxide with primary and secondary amines, 17: 10521
**OXYGEN ISOTOPES O-15**
half life, 17: 11715
nuclear state alignment of 17: 11703
**OXYGEN ISOTOPES O-16**
deuteron scattering cross sections at 2.0 Mev, 17: 11633(R) (TID-17534)
electronic charge distribution at high energy, 17: 11388
exchange of gaseous with oxygen in cobalt compounds, 17: 10634
gamma reactions (γ,n) and (γ,np) on, cross sections for, 17: 11672
gamma reactions (γ,n) at 30.5 Mev, neutron spectra from, 17: 11755
proton inelastic scattering by, dipole-resonance effects on, 17: 11734
proton reactions (p,pn) and (p,2p), 17: 11703
**OXYGEN ISOTOPES O-18**
energy levels, 17: 11299(R) (ANL-6612)
gamma reactions (γ,n) at 30.5 Mev, neutron spectra from, 17: 11756
**OXYGEN SYSTEMS**
Nb–O, mechanical properties of, 17: 11219
$N_2$–$O_2$, radiolysis of, 17: 10509(R) (ORNL-3320(p.30-46))

# P

**PALLADIUM**
heat of vaporization, 17: 10240(R) (NP-12208)
**PALLADIUM ALLOYS**
Pd–Pt, equilibrium solubilities of deuterium and hydrogen in, 17: 10632
**PALLADIUM ISOTOPES**
determination in mixed fission products, radiochemical, 17: 10850(R) (HW-7337(p.77-157))
**PALLADIUM ISOTOPES Pd-104**
energy levels, 17: 11685
**PALLADIUM ISOTOPES Pd-106**
energy levels, 17: 11685
**PANCREAS**
radiation effects on islet-cell tumors in, in rats, 17: 10432
zinc distribution and turnover in, in rats, tracer study, 17: 10275
**PAPER**
production of, design of beta-ray instrument to measure area-weight and water content during, 17: 10980
**PARAMECIUM**
radiation effects on cellular and nuclear growth in, ultraviolet and x-ray, 17: 10408
**PARATHYROID HORMONES**
effects on calcium and strontium in blood serum and bones in rats, mechanism of, 17: 10264
**PARTICLE STATISTICS**
scattering operator for gases, three-particle, 17: 11513
statistical background of resonant states, 17: 11474 (JINR-P-1079)
**PARTICLE TRACKS**
analysis of fast neutron-induced, in silicon, 17: 11272
centering bubble-chamber, device for, 17: 11000 (BNL-6094)
gap lengths of, in nuclear emulsions, photomicrographic techniques for measuring, 17: 10919 (USNRDL-TR-591)
**PARTICLE TRAJECTORIES**
determination in cylindrically symmetric magnetic focusing fields, 17: 10935
problem of branch point, in complex angular momentum plane, 17: 11495 (TID-17731)
**PARTICLES**
atmospheric diffusion and transport, meteorological factors, 17: 10848(R) (HW-73337(p.1-28))
collective motions at finite temperatures, 17: 11414
deposition in circular ducts, 17: 10851(R) (HW-73337(p.158-237))
diffusion in atmosphere, effects of ground cover and vegetation, 17: 10850(R) (HW-73337(p.77-157))
scavenging from air, mechanisms, 17: 10848(R) (HW-73337(p.1-28))
**PEACH BOTTOM POWER REACTOR**
fuel-element permeability, effects of helium stream in-sweeping on, 17: 11189 (GAMD-2638)
**PEAT**
analysis for moisture by neutron stopping, 17: 10559
**PEBBLE BED REACTOR EXPERIMENT (ORNL)**
design studies, 17: 11955(R) (ORNL-3372)
**PERSONNEL**
radiation effects of cyclotron on peripheral blood vessels in, 17: 10444
**PERTURBATION THEORY**
analytic properties of the S-matrix in, Mandestam's work on, 17: 11483 (NP-12436)
analytical properties of many-point functions, 17: 11371
annihilation of antibaryons on baryons, distributions from, 17: 11547
energy eigenvalues in, calculation by Green's functions, 17: 11357
energy spectra of isotopic impurities in lattices, 17: 11410
expansions in many-body problem, 17: 11416
nucleon structure in, 3-meson ($\pi$) effects on isoscalar, 17: 11559
quantized probability amplitudes in, physical effects of, 17: 11425
reactor physics in variational, 17: 11972
spectral line widths in, calculation by Green's functions, 17: 11358
use in analysis of Regge poles, 17: 11905 (JINR-E-1095)
**PHANTOMS**
neutron dosage determinations around and in human, use of nuclear emulsions for, 17: 10868 (UCRL-9967(Rev.))
preparation of neck, for calibration of thyroid iodine-131 uptake measurements, 17: 10343
**PHASE STUDIES**
of binary and ternary transition metal alloys, 17: 11180 (ANL-FGF-337)
**PHENYL PHOSPHATES**
solvent properties for plutonium, thorium, and uranium, 17: 10738 (ORNL-3374)
**PHOSPHATASES**
radiation effects on, protective effects of cysteine against, 17: 10405
**PHOSPHATE GLASS**
preparation of, incorporating radioactive wastes, 17: 12048 (TID-7646 (p.43-51))
**PHOSPHATES**
solvent properties for uranium, 17: 10745 (TID-15773)
use of, in solvent extraction of alkaline earths, 17: 10739(R) (ORNL-TM-27)
**PHOSPHINE OXIDE, TRIOCTYL-**
synergistic effects on solvent extraction by thenoyltrifluoroacetone, 17: 10729 (BNL-6188)
**PHOSPHINE SULFIDE, TRIS(1-AZIRIDINYL)-**
effects on tissue cultures of cervical and ovarian cancer cells, 17: 10261
**PHOSPHINE SULFIDE, TRIBUTYL-**
solvent properties of, for elements, 17: 10754
**PHOSPHONATES**
solvent properties for uranium, 17: 10745 (TID-15773)
**PHOSPHORIC ACID**
use of, in extraction of alkaline earths, 17: 10739(R) (ORNL-TM-27)
**PHOSPHORIC ACID, ALKYL ESTERS**
bis(2-ethylhexyl), solvent properties for iron and uranium in sulfate solutions, 17: 10766
solvent properties of, effects of structure on, 17: 10748 (TID-17726)
**PHOSPHORIC ACID, ARYL ESTERS**
solvent properties of, effects of structure on, 17: 10748 (TID-17726)
**PHOSPHORIC ACID SYSTEMS**
use in extraction of cesium from sodium nitrate, 17: 10739(R) (ORNL-TM-27)
**PHOSPHORS**
performance of cerium-activated glass, 17: 10965
**PHOSPHORUS**
analysis for arsenic, gallium, and manganese, activation, 17: 10562
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
**PHOSPHORUS CHLORIDES**
dissociation and ionization processes in, spectra of, 17: 10630
**PHOSPHORUS ISOTOPES P-31**
energy level transitions in, 17: 11660
gamma reactions (γ,n) in, cross section for, 17: 11653
neutron reactions (n,d) at 14.1 Mev, angular distributions of, 17: 11716
**PHOSPHORUS ISOTOPES P-32**
preparation of monomolecular layer of, 17: 10713
therapeutic uses in polycythemia vera, 17: 10272
treatment of erythremia using, effectiveness of, 17: 10286

**PHOTOCHEMISTRY**
effects of mercaptans and disulfides on reactions of, 17: 10680(R) (TID-17584)
**PHOTOELECTRIC CELLS**
bibliography, 17: 11322 (NP-12429)
**PHOTOGRAPHIC EMULSIONS**
sulphur sensitization of, mechanism of, 17: 10649
**PHOTOMICROGRAPHY**
use in measuring gap lengths of particle tracks in nuclear emulsions, 17: 10919 (USNRDL-TR-591)
**PHOTOMULTIPLIER TUBES**
efficiency of, statistical analysis of, 17: 11041
**PHOTONEUTRONS**
polarization of, from (γ,n) reactions on deuterons, 17: 11551
production on nuclei, cross sections for, 17: 11672
**PHOTONS**
distribution in incoherent beams, 17: 11403
interactions of polarized, with electrons, 17: 11549
interactions with nucleons, theory of radiation damping in, 17: 11916
interactions with protons, pair-production cross sections for, 17: 11516
polarization of multi-Bev, crystal method measurement of linear, 17: 10896 (LNF-62/107)
production in meson ($K^+$) decay, 17: 11523
production of polarized, in lasers, 17: 11549
**PHOTOPROTONS**
production on nuclei, cross sections for, 17: 11672
**PHOTOSYNTHESIS**
reaction mechanisms in energy conversion, 17: 10257 (UCRL-10549)
**PHTHALIC ACID, DIOCTYL ESTER**
use in portable tester for inspection of high-efficiency filters, 17: 10922
**PHYSICAL CHEMISTRY**
book: *Physicochemical Hydrodynamics*, 17: 10813(T)
isotope applications in, 17: 10643
**PHYSICAL CONSTANTS TESTING REACTOR**
neutron flux distribution in, with a cadmium rod at the center, 17: 11303(R) (HW-75228)
**PHYSICS**
branching stochastic processes in, theory of, 17: 10520(T) (NP-tr-946)
research programs on, annual summary, 17: 10243 (NP-12381)
**PINCH DEVICES**
electric measurements on, design of equipment for, 17: 10982
**PINCH EFFECT**
stability, 17: 10240(R) (NP-12208)
stability of cylindrical, 17: 11882
thermal energy concentration in Z, mechanism of, 17: 11846
**PIPES**
neutron streaming in water-$d_2$ in, 17: 11588 (AE-98)
radioautography of interior surfaces, 17: 11004 (HW-SA-2651)
slurry transport in, minimum power requirements , 17: 10809
**PITUITARY GLAND**
histological effects of yttrium-90 on, 17: 10451
**PLANT CELLS**
radiation effects on cell division, tracer study, 17: 10359 (HW-SA-2606)
**PLANTS**
growth of grain and sugar beets, effects of irradiated seed and nitrogen fertilizer, 17: 10442
radiation effects on cytology and morphology of tomato, thermal neutron, 17: 10452
radiation effects on genetics of, studies on, in United Arab Republic, 17: 10416
radioinduced and spontaneous mutations in tomato seed, quantitative comparison of, 17: 10391
radioinduced mutations in *Vicia sativa* L, 17: 10395
**PLASMA**
book: *Plasma Physics and Controlled Thermonuclear Reactions*, 17: 11894
confinement of one-dimensional radiofrequency, theory of, 17: 11852
containment of, configuration of high-frequency electromagnetic field and associated magnetostatic field for, 17: 11845
containment of, development of Picket Fence IIB and III for, 17: 11831(R) (LAMS-2816)
Coulomb interaction in, 17: 11869
cyclotron radiation from hot, 17: 11849
decay of helium, in magnetic field, 17: 11880
decay of helium, in magnetic field, 17: 11890
density in magnetosphere, measurement of, 17: 11447
diagnostics of, methods for, 17: 10240(R) (NP-12208)
diagnostics of, optical interferometry, 17: 11853
dielectric constant of degenerate electron, 17: 11861
diffusion and dynamic friction coefficients for, 17: 11891
diffusion in helium, in magnetic field, 17: 11881
electric conductivity of, anomalous, 17: 11865
electromagnetic wave deflection in, 17: 11827 (AD-277601)
electromagnetic wave confinement by, 17: 11828 (AFCRL-62-63)
electromagnetic wave propagation in cylindrical waveguide containing inhomogeneous, 17: 11843
electromagnetic wave scattering by cylindrical, 17: 11856
electromagnetic wave absorption in classical and quantum, 17: 11864
electromagnetic wave propagation in hydrogen, high-frequency, 17: 11885
electron acceleration in, 17: 11771 (BNL-767(p.106-15))
electron density and temperature in mercury-neon, 17: 11883
electron interactions and oscillations in anisotropic, 17: 11867
energy dissipation in, measurements of, 17: 11893
energy losses by impurity radiation, 17: 11855
energy losses in, from charge motion, 17: 11886
energy transfer in, mechanisms of, 17: 11836 (RADC-TDR-62-186)
hydrogen excitation in collisions in, 17: 11407
injection of, emission light separation during, 17: 11854
instabilities of inhomogeneous, mirror-type micro-, 17: 11875
interactions with high-frequency fields, 17: 10240(R) (NP-12208)
interactions with electromagnetic waves, 17: 11834(R) (NP-12367)
interactions with a charged-particle beam in the presence of a magnetic field, instabilities resulting from, 17: 11863
interactions with electron beams, oscillation spectra from, 17: 11871
ion diffusion across magnetic fields in, anomalous, 17: 11857
ion energy in, design of instrument for measuring, 17: 10897 (MATT-121)
loss of, through magnetic aperture of traps with field increasing toward the periphery, 17: 11841(T) (AEC-tr-5620)
magnetic-field and velocity distributions in, 17: 11352
magneto acoustic wave propagation in fully ionized, equations for dissipation in, 17: 11878
microwave propagation through, in a plasma, 17: 11862
motion in pulsed discharges, 17: 11892
neutrino pair emission by stellar, 17: 11446
neutron production in deuterium, 17: 11866
nonlinear effects in, Vlasov's equation for, 17: 11848
oscillation excitation in, near ion cyclotron frequency, 17: 11851
oscillations in, at cathode sheath, design of diode for studying, 17: 11838(R) (TID-16990)
oscillations in magnetic fields, 17: 11859
oscillations in potassium plasma cell, 17: 11837 (TID-16215)
oscillations in, stability of longitudinal, 17: 11888
oscillations of, mode-coupling damping of, 17: 11870
particle diffusion across magnetic fields in positive-column, 17: 11868
positive column contraction in, theory of, 17: 11874
probe theory for, 17: 11876
processes in, theory of irreversible, 17: 11832 (MATT-106)
production of, development of cells for, 17: 11311(R) (LAMS-2796)
properties of high-density, 17: 11826(R) (AD-273961)
properties of nitrogen, to 15000°K, 17: 11877
radiation emission by free electrons in, 17: 11829 (ASD-TR-61-179 (Vol.I))
resonances of small sphere of, in magnetic fields, 17: 11858
spectra of, profiles of Stark-broadened Balmer lines in hydrogen, 17: 11860
stability of axially symmetric, 17: 11887
stability of non-uniform, low-frequency, 17: 11847
stability of torus with surface currents, 17: 11872
stability of weakly ionized, in homogeneous magnetic field, 17: 11889
static potential of infinite cylinder immersed in a moving and low-density, 17: 11844
theory of non-contracting positive columns under the effect of negative ions, 17: 11873
turbulence of, theoretical analysis of, 17: 11833 (MATT-114)

wave coupling at discontinuities in, 17: 11850
**PLASTIC DEFORMATION**
dislocation concepts of strain rate effects in, 17: 11198 (UCRL-10498)
of polycrystalline aggregates, 17: 11196 (UCRL-10152)
**PLASTIC FILMS**
fabrication of thin, 17: 10911 (TID-16251)
**PLASTICS**
physical properties of glass-filled diallyl phthalate, 17: 10239(R) (MLM-1140)
radiation effects on, testing for transuranic process construction, 17: 10741(R) (ORNL-TM-313)
**PLATES**
neutron currents in asymmetric configuration, 17: 11596 (TID-15752)
**PLATING**
techniques for, development of, 17: 11130
**PLATINUM**
radiation effects, 17: 11129
separation from metal ionic mixtures, electrochromatographic, 17: 10753
**PLATINUM ALLOYS**
Pd–Pt, equilibrium solubilities of deuterium and hydrogen in, 17: 10632
Pt–Rh, thermal conductivity and expansion at 500 to 2500°F, 17: 11199 (UCRL-13061)
Pt–Ru, thermal conductivity and expansion at 500 to 2500°F, 17: 11199 (UCRL-13061)
**PLATINUM ELECTRODES**
testing in potassium chlorate and chloride, capacity–potential behavior of, 17: 11135(T,R) (EURAEC-483)
thermionic emission in gases, 17: 11435
**PLATINUM ISOTOPES Pt-192**
decay of, electron-gamma angular correlation in, 17: 11666
energy levels, 17: 11685
**PLUTONIUM**
analysis for soluble silicon by cation exchange, spectrographic, 17: 10548
criticality of hydrogen-moderated fully reflected sphere of, effects of scatterers on, 17: 11303(R) (HW-75228)
deposition in bones in rachitic rats, tracer study, 17: 10330
deposition in bone, reaction mechanisms, 17: 10331
deposition in bone, reaction mechanisms, 17: 10332
deposition in bones in dogs, histopathologic effects of, 17: 10346
determination by potentiometric titration, 17: 10737 (NBL-189)
determination in biological materials, radiochemical, 17: 10298(R) (COO-226(p.58-65))
determination in oxides, 17: 11108(T,R) (EURAEC-307)
determination in reactor fuels, 17: 11303(R) (HW-75228)
determination in urine, radiometric, 17: 10527 (ANL-6637(p.33-42))
handling of, design of shipping container for, 17: 10862 (RFP-290)
maximum permissible deposition dose in man, 17: 10337
maximum permissible body burden for man, 17: 10338
metabolism in rats, tracer study, 17: 10325
reactions with yttrium at high temperatures, 17: 10239(R) (MLM-1140)
removal from blood in rats, effectiveness of diethylenetriaminepentaacetic acid, 17: 10327
removal of deposited, evaluation of chelating agents, 17: 10334
separation from fuel reprocessing solutions, 17: 10519(T,R) (EURAEC-460)
separation from nitrate medium using aliphatic ketones, 17: 10758
separation from thorium and uranium by solvent extraction using butyl phenylphosphates and butyl phosphates, 17: 10738 (ORNL-3374)
separation from uranium by ion exchange, 17: 11108(T,R) (EURAEC-307)
separation from uranium carbide and oxide, 17: 10737 (NBL-189)
separation of, by amine extraction from purex raffinate, 17: 10739(R) (ORNL-TM-27)
solvent extraction from purex wastes by amines, 17: 10740(R) (ORNL-TM-181)
thermodynamic properties at 298.16 to 2500°K, 17: 10593 (LA-2813)
toxic effects in mice, 17: 10317
toxic effects in rats, synergistic effects of x radiation, 17: 10318
transfer from plasma to milk in sheep, tracer study, 17: 10326
urinary excretion in man, 17: 10339
wound contamination, measurement with x-ray scintillation spectrometer, 17: 10849(R) (HW-73337(p.29-76))
**PLUTONIUM ALLOYS**
corrosion studies, 17: 11126
Ce–Cu–Pu, phase studies, 17: 10239(R) (MLM-1140)
Pu–Th–U, phase studies, 17: 11935(R) (ANL-6658)
**PLUTONIUM CARBIDES**
preparation and properties of, 17: 11935(R) (ANL-6658)
PuC–UC, phase studies, 17: 11181 (ANL-FGF-345)
**PLUTONIUM CHLORIDES**
reactions with aluminum chlorides, complex formation in, 17: 10586 (HW-SA-2597)
**PLUTONIUM(III) CHLORIDES**
reduction of, flowsheets for calcium, 17: 10582 (HW-SA-1973)
separation from fused salt media by solvent extraction, 17: 10765
**PLUTONIUM COMPLEXES**
with chloride, anion exchange and nonaqueous studies, 17: 10585 (HW-SA-2596)
**PLUTONIUM HYDROXIDES**
calcination, 17: 11108(T,R) (EURAEC-307)
**PLUTONIUM IONS**
potentiometric behavior in acetates, 17: 10654
**PLUTONIUM ISOTOPES**
toxic effects in dogs, 17: 10294(R) (COO-226)
**PLUTONIUM ISOTOPES Pu-239**
body burden estimates based on urinalysis data, 17: 10340
content in man, estimate from urinalysis data, 17: 10524 (ANL-6637 (p.13-21))
critical concentrations in aqueous solutions, 17: 11303(R) (HW-75228)
detection and measurement in air, design of semiconductor detector for, 17: 11012 (UCRL-6692)
determination in air, coincidence monitor for, 17: 10532 (HW-SA-2554)
distribution and excretion of inhaled, in dogs, 17: 10321
distribution in mice, autoradiography of injected, 17: 10260
distribution in skeleton in dogs, long-term study, 17: 10329
distribution in tissues and removal by chelation, effects of physical state, 17: 10523 (ANL-6637(p.5-8))
dosage determinations in tissue, 17: 10301(R) (COO-226(p.78-85))
metabolism in dogs, long-term study, 17: 10319
neutron reactions at 0.061 to 6.5 kev, capture-to-fission ratio in, 17: 11936(R) (ANL-6672)
pathological effects in liver in dogs, 17: 10328
pathological effects in man, 17: 10338
pathological effects of injected, in dogs, 17: 10303(R) (COO-226(p.95-127))
removal of internally deposited, effectiveness of DTPA, 17: 10336
toxic effects in dogs, long-term study, 17: 10320
toxic effects of inhaled, in dogs, 17: 10322
toxic effects of inhaled, in mice, 17: 10323
toxicity in dogs, 17: 10295(R) (COO-226(p.3-33))
**PLUTONIUM NITRATES**
critical mass measurements, 17: 11303(R) (HW-75228)
criticality studies on spherically contained solutions of, 17: 11459 (HW-SA-2432(Rev.))
**PLUTONIUM OXALATES**
calcination, 17: 10239(R) (MLM-1140)
**PLUTONIUM OXIDES**
$PuO_2$–$UO_2$, radiation effects, 17: 11117(T,R) (EURAEC-491)
$PuO_2$–$UO_2$, thermal expansion, 17: 11203(T) (EURAEC-434)
**PLUTONIUM(IV) OXIDES**
compaction of powders by vibration, 17: 11108(T,R) (EURAEC-307)
enthalpy at 0 to 650°C, 17: 11108(T,R) (EURAEC-307)
irradiation testing, research program, 17: 10249(T,R) (EURAEC-301)
sintering, 17: 11108(T,R) (EURAEC-307)
thermal expansion, 17: 11108(T,R) (EURAEC-307)
thermal expansion, 17: 11203(T) (EURAEC-434)
$PuO_2$–$UO_2$, radiation effects, 17: 11154 (CEND-153(Vol.II)(p.3-38))
$PuO_2$–$UO_2$, sintering, 17: 11108(T,R) (EURAEC-307)
**PLUTONIUM RECYCLE TEST REACTOR**
fuel element cooling by transverse air flow in examination cell, 17: 10793 (HW-72097(Rev.))
heavy water losses, 17: 12016
**PLUTONIUM SILICIDES**
preparation and properties of, 17: 11935(R) (ANL-6658)

**PLYWOOD**
properties under shock loading, 17: 11937(R) (ARF-4132-16)
**PNEUMATIC SYSTEMS**
development of radiation-resistant, for flight vehicles, 17: 10774(R) (GDC-63-001)
**POLAROGRAPHY**
of uranium, 17: 10541(T,R) (EURAEC-400)
technique for determination of yields in radioinduced oxidation of iron(II), 17: 10569
**POLONIUM ISOTOPES Po-210**
alpha decay of, measurement and theory of M photon yield in, 17: 11616 (BNL-6166)
as alpha source in analysis of concentration products, 17: 10570
reactions with rare earths at high temperatures, 17: 10239(R) (MLM-1140)
**POLONIUM ISOTOPES Po-216**
alpha half life of, 17: 11632 (TID-16202)
**POLONIUM ISOTOPES Po-218**
pollution of atmosphere by, method for determining, 17: 10560
**POLYCRYSTALS**
plastic deformation of, review of related mechanisms in, 17: 11196 (UCRL-10152)
**POLYCYTHEMIA**
treatment using phosphorus-32, effectiveness of, 17: 10286
treatment with phosphorus-32, effectiveness of, 17: 10272
**POLYMERS**
radiation chemistry of aqueous solutions of polyvinylpyrrolidone and polyethyleneoxide, effects of additives, 17: 10690
radioinduced crosslinking and polymerization of, review on, 17: 10684
**POLYPHENYLS**
critical heat fluxes for reactor coolants, 17: 10800 (NAA-SR-7954)
radiolysis, 17: 11268(R) (TID-16999)
**POPULATIONS**
effects of environmental contamination by radium-226 on average daily intake, 17: 10529 (ANL-6637(p.59-84))
effects of natural and radioinduced lethals in Drosophila, 17: 10256(R) (TID-17699)
**PORTLAND CEMENTS**
properties evaluation for use in low-background counting facility, 17: 11903 (UCRL-10475)
**POSITRON BEAMS**
design and performance of "AdA" accumulator ring, 17: 11820
**POSITRONIUM**
decay in teflon, 17: 11627 (TID-15088)
spectra of, calculation from electron scattering amplitudes, 17: 11548
**POSITRONS**
annihilation in metals, 17: 11539
annihilation reactions with conduction electrons of ordered alloys, 17: 11275
detection from deposited radioisotopes, performance of multi-detector system, 17: 10357 (BNL-6572)
scattering by atomic hydrogen at 11.0 to 54.4 ev, 17: 11390
scattering by atomic hydrogen, zero-order partial wave shifts for elastic, 17: 11328 (TID-15769)
**POTASSIUM**
corrosive effects on metals at 500 to 1800°F, 17: 11129
effects of gaseous, on alloys at high temperatures, 17: 12036(R) (SY-5396-R3)
heat transfer from boiling, development of loop for study of, 17: 10791 (BNL-6142)
heat transfer of boiling, measurement of, 17: 12036(R) (SY-5396-R3)
heat transfer under boiling and condensing conditions, 17: 11098(R) (NP-12433)
plasma oscillations in, near ion cyclotron frequency, 17: 11851
radiation effects on urinary excretion of, x, 17: 10463
**POTASSIUM ACID FLUORIDES**
crystal structure, 17: 10608 (UCRL-10197)
**POTASSIUM BROMORHENATES**
heat capacity, 17: 10514(R) (ORNL-3320(p.104-25))
**POTASSIUM CARBONATES**
$Li_2CO_3$–$K_2CO_3$–$Na_2CO_3$, heat transfer to uranium from molten, 17: 10805 (Y-1420)
**POTASSIUM CHLORIDE CRYSTALS**
M-center formation in additively colored, 17: 10653
radiation effects on F- and M-center concentrations in, 17: 10711
radiation equilibrium of F and M centers in, 17: 11393
**POTASSIUM CHLORIDES**
analysis for cesium, spectrometric, 17: 10565
$AlCl_3$–LiCl–KCl, immiscibility gap in molten phase, 17: 10587 (HW-SA-2621)
$CdCl_2$–KCl, electric conductivity and ion formation in liquid, 17: 10513(R) (ORNL-3320(p.98-103))
K–KCl, electric conductivity, 17: 10513(R) (ORNL-3320(p.98-103))
$MgCl_2$–KCl–NaCl, solvent properties for cerium and uranium from bismuth–magnesium alloy at 500°C, 17: 10581 (BNL-639)
**POTASSIUM CYANIDES**
preparation of carbon-14-labeled, 17: 10517 (PAN-336/XIII)
**POTASSIUM FERROCYANIDES**
radioinduced oxidation of, comparison with ferrous sulfate, 17: 10692
**POTASSIUM FLUORIDES**
LiF–KF, molar enthalpies of mixing in, 17: 10514(R) (ORNL-3320 (p.104-25))
**POTASSIUM HYDROXIDES**
oxidative effects on deuterium and hydrogen on rotating disk electrode, 17: 10628
reactions with rare earth nitrilotriacetates at 25°C, 17: 10501 (IS-458)
**POTASSIUM IODIDES**
radiolysis effects on yields in liquid methanol, 17: 10699
**POTASSIUM ISOTOPES**
measurement of, for use in age measurements, 17: 10243 (NP-12381)
**POTASSIUM ISOTOPES K-39**
nuclear spin flop-in transitions, 17: 11299(R) (ANL-6612)
**POTASSIUM ISOTOPES K-42**
half life, 17: 11628 (TID-15849)
production of carrier-free, from enriched calcium-42, 17: 11651
**POTASSIUM ISOTOPES K-43**
production of carrier-free, from enriched calcium-43, 17: 11651
**POTASSIUM NITRATES**
electric conductivity and density of, temperature effects on, 17: 10605(R) (TID-17816)
magnetic resonance of irradiated, 17: 10514(R) (ORNL-3320(p.104-25))
salting-out properties in uranyl nitrate extraction from aqueous solutions, 17: 10770
$KNO_3$–$NaNO_3$, properties of cobalt(II) ions in, effects of bromides, chlorides, and fluorides on, 17: 10605(R) (TID-17816)
$LiNO_3$–$KNO_3$, properties of cobalt-II ions in, effects of bromides, chlorides, and fluorides on, 17: 10605(R) (TID-17816)
**POTASSIUM SULFATES**
reactions with alkaline earth and rare earth elements, thorium, and uranium, precipitation, 17: 10621
**POTASSIUM SYSTEMS**
K–KCl, electric conductivity, 17: 10513(R) (ORNL-3320(p.98-103))
K–Na–$UO_2$, studies of slurry as potential fuel, 17: 11077 (ANL-6644)
**POTENTIOMETERS**
design and performance for voltage measurements in a pulsed toroidal gas discharge, 17: 10982
**POWDERS**
analysis of, technique for spectrographic, 17: 10952
**POWER REACTORS**
control equipment and instrumentation development for gas-cooled, 17: 10994
description of Ravenswood, for hazards summary report, 17: 10858 (NP-12466(Vol.I))
design description of Jülich high-temperature gas-cooled, 17: 11998(T) (AEC-tr-5484)
design of advanced gas-cooled, 17: 11955(R) (ORNL-3372)
design optimization of heavy-water, 17: 11979(R) (DP-805)
drawings for Ravenswood hazards summary report, 17: 10860 (NP-12466 (Vol.III))
economics of gas-cooled, heavy-water, natural-uranium, 17: 12001
fuel performance analysis for graphite gas-cooled, 17: 11999(T) (AEC-tr-5610)
hazards analysis for Polish, 17: 11973
hazards summary for Ravenswood, preliminary report, 17: 10859 (NP-12466(Vol.II))

instrumentation for water-cooled, review, 17: 10996
performance of, with cesium diodes, 17: 11315 (NAA-SR-7661)
review of developments, 17: 12009
site data for Ravenswood, 17: 10861 (NP-12467)
stability criteria for, 17: 12004
**POWER SUPPLIES**
design of stable high voltage, for scintillation detectors, 17: 11022
for space vehicles, review, 17: 12035 (NP-12492)
**PRASEODYMIUM**
viscosity of liquid, 17: 10239(R) (MLM-1140)
**PRASEODYMIUM CARBIDES**
free energy of formation of mono-, standard, 17: 10644
**PRASEODYMIUM ISOTOPES Pr-141**
carbon nucleus reactions with, measurements of various parameters of, 17: 11645 (UCRL-10099)
nuclear spin of 142-kev level, 17: 11705
**PRASEODYMIUM ISOTOPES Pr-143**
energy levels of, half life of first excited, 17: 11689
**PRASEODYMIUM ISOTOPES Pr-144**
separation from cerium-144, carrier-free, 17: 10762
**PRASEODYMIUM NITRATES**
toxic effects in rats, synergistic effects of x irradiation, 17: 10484(R) (NP-12251(p.90-8))
**PRASEODYMIUM SELENIDES**
thermoelectric properties of sesqui-, 17: 11292 (AD-277043)
**PREDNISOLONE**
protective effects against post radiotherapy symptoms in man, 17: 10268
**PRESSURE DROP**
in two-phase flow in channels, 17: 10792(R) (GEAP-4148)
**PRESSURE REGULATORS**
development of, for use in radiation-resistant pneumatic systems, 17: 10774(R) (GDC-63-001)
**PRESSURE VESSELS**
development for reactor containment, 17: 11937(R) (ARF-4132-16)
development of, for use in radiation-resistant pneumatic systems, 17: 10774(R) (GDC-63-001)
radiation effects on, neutron, 17: 11287
stress relief, review, 17: 12014
testing of Armco iron for, 17: 11188(R) (EURAEC-485)
**PRESSURIZED WATER REACTORS**
design concept description for ship propulsion, 17: 12020
**PROMETHIUM**
separation from yttrium by pulsed solvent extraction, 17: 10746 (TID-15792)
solvent extraction using thenoyltrifluoroacetone, synergistic effects of tributyl phosphate and trioctylphosphine oxide, 17: 10729 (BNL-6188)
**PROMETHIUM ISOTOPES Pm-147**
sorption by gold, stainless steel, tantalum, and titanium surfaces, 17: 11244
**PROMETHIUM ISOTOPES Pm-150**
decay scheme, 17: 10506(R) (ORNL-3320(p.1-15))
**PROMETHIUM ISOTOPES Pm-151**
decay of, 17: 11652
**PROPANE**
reactions with mercury, effects of deuterium on quenching cross sections in, 17: 10685
**PROPANE, 2-METHYL-**
reactions with mercury, effects of deuterium on quenching cross sections in, 17: 10685
**2-PROPANOL**
heat transfer to steam-heated tubes, effects of tube surface voltage on, 17: 10801(R) (NYO-10345)
**PROPENE**
reactions with mercury, effects of deuterium on quenching cross sections in, 17: 10685
**PROPENE, 2-METHYL- POLYMERS**
radiation effects on, in carbon tetrachloride solutions, 17: 10709
**PROPENE POLYMERS**
beta sorption and glass transition in, effects of temperature on, 17: 11282
**PROPIONIC ACID**
decomposition of, uranyl sensitized photo-, 17: 10697
**PROPIONITRILES**
$\beta$-$\beta'$-iminodi-, effects of, on radiation injury in central nervous system in mice, 17: 10263
**PROPIOPHENONE, p-AMINO-**
toxicity, physiological effects, and radioprotective effects in rats and mice, 17: 10483(R) (NP-12251(p.67-89))
**PROPORTIONAL DETECTORS**
design and performance of proton-recoil, for fast neutron spectrometry, 17: 11002 (CNEN-158)
design of, for monitoring beta stack gases, 17: 11017
performance, for detection of weak beta particles, 17: 10850(R) (HW-73337(p.77-157))
performance in carbon-14 dating, 17: 10834
**PROPULSION**
development of tungsten emitters for ion systems for, 17: 11080 (ASD-TDR-62-756)
nuclear systems for space, closed-loop dynamics of, 17: 12037
propellants for electrical, 17: 11302 (ASD-TR-61-150(Pt.II))
systems for space vehicles, review, 17: 12035 (NP-12492)
**PROPYLAMINE**
distillation of, with carbon dioxide, isotope effects in, 17: 10521
**PROTACTINIUM**
content stability in solution, 17: 10246(R) (ORNL-TM-403)
determination in aluminum as trace impurity, activation, 17: 10546
sorption by silica gel and Vycor glass, 17: 10246(R) (ORNL-TM-403)
**PROTACTINIUM CHLORIDES**
reactions with aluminum chlorides, complex formation in, 17: 10586 (HW-SA-2597)
**PROTACTINIUM ISOTOPES Pa-231**
spectral analysis of, 17: 11670
**PROTACTINIUM ISOTOPES Pa-233**
neutron cross sections and resonance integrals, 17: 10506(R) (ORNL-3320(p.1-15))
**PROTACTINIUM ISOTOPES Pa-234**
electron internal conversion and $L$ fluorescence, 17: 11657
**PROTEINS**
protective effects of bile, against radiation damage in bilirubin and biliverdine, 17: 10376
radiation effects on metabolism of, in barley seedlings, 17: 10456
radiation effects on synthesis of, in *Paramecium aurelia*, 17: 10408
sulfur metabolism, tracer study, 17: 10312(T) (AEC-tr-5600)
synthesis by chloroplasts, tracer studies of role of lipoproteins in, 17: 10314
**PROTON BEAMS**
deflection of 50-Mev, methods for, 17: 11807 (TID-17829)
ejection from synchrotrons, pulsed-magnet, 17: 11801 (TID-17652)
experiments with colliding, use of synchrotron in, 17: 11775 (BNL-767(p.172-6))
reactions in heavy concrete at 24 Bev, star densities produced by, 17: 11489 (ORNL-3367)
size control at Argonne ZGS, 17: 11800 (TID-17642)
**PROTON SHIELDING**
efficiency evaluation, 17: 11898 (N62-10900(Pt.III))
evaluation of aluminum as, for space vehicles, 17: 11902 (ORNL-3317)
evaluation of superconducting magnetic, 17: 11899 (N62-10900(Pt.IV))
**PROTON SOURCES**
high-intensity, with plasma contraction by inhomogeneous field, 17: 11777 (BNL-767(p.224-53))
**PROTONS**
acceleration from 50 Mev to 12.5 Bev in Argonne ZGS, 17: 11494 (TID-17627)
collimation of recoil, design of instrument for, 17: 10889 (AD-252467)
energy distribution from deuteron stripping reactions at 13.6 Mev, 17: 11742
form factors for, 17: 11506
interactions with protons, production of mesons($\omega^+$) in, 17: 11465 (BNL-6646)
interactions with mesons($\mu^-$) in hydrogen (liquid), estimation of, 17: 11480 (LNF-62/109)
interactions with mesons($K^-$), 17: 11487 (NP-12488)
interactions with electrons, weak-transfer elastic, 17: 11506
interactions with photons, pair-production cross sections for, 17: 11516

interactions with mesons ($\pi^-$), one-pion exchange model in, 17: 11535
interactions with deuterons, slightly inelastic, 17: 11540
interactions with electrons, meson ($\pi$) production by, 17: 11543
interactions with mesons ($K^-$), branching ratios for, 17: 11560
interactions with mesons ($\pi$), isotopic spin independence in, 17: 11561
interactions with gamma radiation at 550 Mev, cross sections for, 17: 11564
interactions with gamma radiation, meson ($\pi^0$) production amplitude, 17: 11565
interactions with hyperons ($\Xi^-$) at rest, 17: 11567
interactions with protons at low energies, 17: 11568
interactions with photons, differential cross sections for, 17: 11574
interactions with protons at 180 Mev, calcium-40 proton shell structure study in, 17: 11677
interactions with mesons ($K^-$), angular distribution of mesons ($\pi^-$) produced in, 17: 11299(R) (ANL-6612)
interactions with neutrons and protons, quantum mechanical relations for,
interactions with hyperons ($\Lambda$), cross section for elastic, 17: 11533 17: 11932
interactions with protons at 50 Mev, polarization in, 17: 11525
interactions with mesons ($\pi$), meson ($\pi$-$\pi$) amplitudes in, 17: 11518
polarization in boron-11 (d,p) reactions, computer programming for analyzing, 17: 11639(R) (TID-17720(p.62-78))
production in meson ($\pi^-$) capture in emulsion, 17: 11679
reactions (p,$\alpha$) with carbon-12, boron-9 excited state production in, 17: 11683
reactions (p,$\alpha$) with tin-120 to 22 Mev, 17: 11696
reactions (p,$\alpha$) with tin-120 at 12 and 18 Mev, 17: 11697
reactions (p,d), scattering theory for, 17: 11492 (TID-16044)
reactions (p,n) in heavy nuclei, resonance peaks in, 17: 11681
reactions (p,2p) in iron-57 and zinc-68 at 400 Mev to 6.2 Bev, cross sections and excitation functions for, 17: 11650 (UCRL-10531)
reactions with aluminum and beryllium, bremsstrahlung production in, cross sections for, 17: 11644 (UCRL-7001)
reactions with emulsion nuclei at 26.7 Bev/c, meson production in, 17: 11611 (AD-277387)
reactions with gold, indium, and uranium at 2.9 Bev, nuclear charge distributions in, 17: 11727
reactions with hydrogen atoms, ionization in, 17: 11407
reactions with magnesium-26, 661-kev resonance gamma spectra from, 17: 11680
reactions with nuclei (p,p'$\gamma$), angular correlation symmetries in, 17: 11684
reactions with rhodium at 5 to 12 Mev, neutron spectra from, 17: 11631 (TID-16049)
reactions with uranium-238 at 0.1 to 6.2 Bev, excitation functions and nuclear charge dispersion in, 17: 11725
reactions with uranium-238 at 0.5 to 6.2 Bev, cross section and recoil studies of, 17: 11726
scattering by chromium and zinc isotopes at 6.9 Mev, 17: 11656
scattering by magnesium-24 at 6.9 Mev, angular distributions from elastic and inelastic, 17: 11743
scattering by nickel-64 and zinc-64 at 9.6 and 11.7 Mev, differential cross sections for, 17: 11643 (UCRL-6930)
scattering by nuclei, angular correlation symmetries in inelastic, 17: 11684
scattering by nuclei, dipole-resonance effects on inelastic, 17: 11734
scattering by nuclei, quasi-elastic, 17: 11736

**PSEUDOUREA, 2-(2-AMINOETHYL)-2-THIO-**
effects on metabolism of thymidine in intestine of irradiated mice, 17: 10486 (TID-15931)
protective effects against radiation injury, 17: 10480(R) (NP-12251 (p.22-33))
protective effects against radiation injury to cells in tissue culture, 17: 10491

**PUERTO RICO POWER REACTOR**
fuel-assembly fabrication for, superheater, 17: 11165 (GNEC-179)

**PULSE ANALYZERS**
circuit design for, high-level linear gate, 17: 11031
design of electrostatic, for ion beam analysis, 17: 11010 (TID-16311)
design of multichannel with memory, 17: 11043
multidimensional, review of, 17: 10976

**PULSE INTEGRATORS**
design for recording of radiocardiography changes, 17: 11024

**PUMPS**
development of seals for high-pressure, 17: 10778(R) (NYO-9742)
development of seals for high-pressure, 17: 10779(R) (NYO-9743)

**PUREX PROCESS**
corrosive effects of waste on stainless steel, 17: 10246(R) (ORNL-TM-403)
precipitation of strontium from IWW waste, 17: 10246(R) (ORNL-TM-403)
sulfate volatility of high-sulfate waste, 17: 10246(R) (ORNL-TM-403)

**PYRIDINE**
preparation of, from methylene iodide and sodium pyrrole, 17: 10669(T) (NP-tr-942)
reactions with niobium and tantalum halides, 17: 10500 (IS-385)

**PYRIDINES**
use in ion-exchange separation of sodium from other metals, 17: 10747 (TID-15923)

**PYRIDOXINE**
protective effects against nausea and vomiting in radiation sickness, 17: 10489

**PYROPHOSPHORIC ACID**
solvent properties for monazite sand, 17: 10556

**PYRROLE**
reactions of substituted, with bromoform and chloroform, 17: 10668(T) (NP-tr-941)
reactions with methylene iodide to form pyridine, 17: 10669(T) (NP-tr-942)

**PYRROLIDONE, VINYL- POLYMERS**
use of iodine-131-labeled, for localization of brain tumors in cats, 17: 10287

**PYRUVIC ACID**
metabolism by irradiated bacteria, 17: 10468

# Q

**QUALITY CONTROL**
phantom gage for toleranceing of parts, 17: 10913 (TID-17740)

**QUANTUM ELECTRODYNAMICS**
covariant quantization of electrodynamic field in non-varying photon mass, 17: 11575
dispersion relations in, method for writing, 17: 11468 (JINR-D-1108)
multipole expansion in, 17: 11350
quantization of electromagnetic field, 17: 11911
relations of electron infrared factors to positronium spectra, 17: 11548

**QUANTUM MECHANICS**
angular momentum transport in statistical, 17: 11917
annihilation of antibaryons on baryons, distributions from, 17: 11547
baryon excited states in, unitary-symmetry model for, 17: 11557
conditions for field theory to be relativistic, 17: 11926
energy eigenvalues of many-body systems in, 17: 11357
energy spectra of isotopic impurities in lattices, 17: 11410
excitons in superconductors, impurity-scattering effects on, 17: 11412
field interactions in, mathematical basis of, 17: 11923
generalization of Planck's radiation law in $h$-$c$-$J$ theory, 17: 11429
generalized momentum operators in, Hermitian properties of, 17: 11339 (WIS-AEC-34)
group theory applications, lectures, 17: 11906 (NP-12434)
Hilbert-space transformations for relativistic particles, 17: 11579
linear response of systems in thermal equilibrium to external disturbances, 17: 11582
localizability of systems in, 17: 11929
momentum region in Thomas-Fermi theory, modification of, 17: 11309 (LA-2750)
multipole expansion in, 17: 11350
particle collective motion at finite temperature, 17: 11414
phonon-phonon interactions in Bose systems, 17: 11411
probability-amplitude fields in, physical nature of, 17: 11425
relaxation phenomena in spin and harmonic oscillator systems, 17: 11920
representations of the rotation group, 17: 11569
scattering amplitudes in, analytic properties of partial-wave, 17: 11572
semiclassical treatment of problems in, 17: 11932
spectral line widths in, calculation by Green's functions, 17: 11358
spin-0 and spin-1 bosons in, 17: 11509

theory of radiation damping, 17: 11916
transformations for spin-½-particle–field interactions in, 17: 11508
variational analyses of reactor physics in, 17: 11972
Wigner distribution and quantum-mechanical phase space, 17: 11927
**QUARTZ**
adsorptive properties for benzene drops under water, effects of hysteresis angles on, 17: 11091(R) (MITS-49)
adsorptive properties for water drops under benzene, effects of hysteresis angles on, 17: 11091(R) (MITS-49)
analysis for germanium, activation, 17: 10574
**8-QUINOLINETHIOL**
solvent properties for metal ions, 17: 10768
**8-QUINOLINOL**
spectra of, effects of substitutions on absorption, 17: 10667 (TID-15433)
**8-QUINOLINOL CHELATES**
spectra of, effects of substitutions on absorption, 17: 10667 (TID-15433)

# R

**RABBITS**
radiation effects on skin grafting on, role of antibodies in, 17: 10425
radiation effects on thoracic lymph of, gamma, 17: 10462
radiation sickness of, effects of, on maturation and proliferation of bone marrow in, 17: 10495
radioinduced dermititis on ears of, reactions of boron-10 and thermal neutrons, 17: 10475
synthesis of DNA in peripheral blood cells in, effects of colloidal silver, hemorrhage, and x radiation on, 17: 10291
**RADAR**
scattering by upper-atmosphere plasma, 17: 11447
**RADIATION**
angular correlations of, external field effect on, 17: 11386
biological efficiency of, ionization method for determination of relative, 17: 10448
book: *On Practical Problems in Ionizing Radiation Dosimetry*, 17: 10879
chromosome breakage induced by, in salivary gland and sperm in Drosophila, 17: 10403
detection and measurement, evaluation of Portland cements for low-background counting facility for, 17: 11903 (UCRL-10475)
dose distributions from oblique tube for sieve irradiation, 17: 10878
dosimetry of, review of chemical methods for, 17: 10998 (AERE-R-4189)
effects of, on central nervous system in mice injected with stimulants, 17: 10263
effects of, on survival of rats, effects of isogenic bone marrow and lymphocyte injections on, 17: 10437
effects of, on survival, in *Drosophila melanogaster*, 17: 10277
effects on agriculture genetics, studies on, in United Arab Republic, 17: 10416
effects on bacteria, biochemical and genetic, 17: 10366(R) (TID-17697)
effects on damping constants of electron oscillations in synchrotrons, 17: 11787 (LNF-62/96)
effects on flour flavor and odor, germination, respiration, and surface molds on wheat, cathode, 17: 10374
effects on immunity in bone marrow and lymph node chimeras, 17: 10474
effects on lever function in cancer patients, 17: 10464
effects on peripheral blood vessels in cyclotron personnel, 17: 10444
effects on reproductive capacity of mammalian tumor leukemic cells *in vivo*, ionization density, 17: 10396
effects on survival of rats, effects of surgical isolation of intestinal segment on, 17: 10378
emission by electrons in synchrotrons, coherent, 17: 11770 (BNL-767 (p.100-5))
genetic effects in *Escherichia coli*, 17: 10364(R) (TID-17690)
genetic effects in Drosophila, 17: 10256(R) (TID-17699)
induction of pneumonitis in rats by, 17: 10377
mutagenic effects on "Cappelli" wheat, 17: 10389
pathological effects in mice, 17: 10360 (TID-15850)
**RADIATION CHEMISTRY**
book: *Radiolysis of Hydrocarbons*, 17: 10722
conference on, Moscow, 1960, 17: 10721
developments in applied, review on, 17: 10684
processes in, review of, 17: 10720
**RADIATION DAMAGE**
kinetics of, 17: 11348
**RADIATION DETECTION INSTRUMENTS**
calibration and use of portable, at Sandia, 17: 11007 (TID-15765)
circuits for transistorized, 17: 10960
description for monitoring plutonium-239 in air, 17: 10532 (HW-SA-2554)
design and performance of, for personnel protection and reactor control, 17: 11019
design of area gamma monitoring system for temperature compensation, 17: 11014 (USNRDL-TR-604)
development for use as personnel monitors, 17: 10852(R) (HW-73337 (p.238-97))
development for use as air monitors, 17: 10852(R) (HW-73337(p.238-97))
efficiency of, method for determining, 17: 11042
use of semiconductor circuits in, review, 17: 10957
**RADIATION DETECTION INSTRUMENTS (ION CURRENT TYPE)**
calibration of shadow shield whole-body counter, 17: 10849(R) (HW-7337(p.29-76))
design and performance of sensitive muscle-equivalent, for environmental monitoring, 17: 11011 (TID-17824)
development of portable, 17: 10968
performance as lung counter, 17: 10849(R) (HW-73337(p.29-76))
performance for external scanning of low-level gamma-emitting radio-isotopes, 17: 10344
**RADIATION DETECTION INSTRUMENTS (PULSE TYPE)**
amplification scheme for, using semiconductor detectors, 17: 11045
anodes for G-M gas flow, replacement parameters for, 17: 11013 (UCRL-6845)
design and performance with liquid scintillators for absolute activity measurements, 17: 10966
design and performance for human body internal contamination measurements, 17: 10963
design and performance with scintillation detectors, review, 17: 10964
design for flux mapping in inaccessible reactor core regions, 17: 10988
design for use in power reactors, 17: 10986
design of hand monitor for simultaneous alpha and beta measurement, 17: 10962
design of multichannel, 17: 11049
design of transistorized counting-rate meter for, 17: 10959
multidimensional analyzers for, review of, 17: 10976
performance of multi-detector system and digital computer for localization of brain tumors by positron scanning, 17: 10357 (BNL-6572)
**RADIATION DETECTORS**
design for gamma and neutron logging in drill holes, 17: 10836
design of semiconductor galvanometer for, 17: 10958
development, 17: 10243 (NP-12381)
development for use as personnel monitors, 17: 10852(R) (HW-73337 (p.238-97))
development for use as air monitors, 17: 10852(R) (HW-73337(p.238-97))
development of improved-accuracy, 17: 10889 (AD-252467)
volume in active homogeneous media, effective, 17: 11040
**RADIATION EFFECTS**
on reactor fuels, bibliography, 17: 11269 (VDIT-16(2.4))
theory, 17: 11129
**RADIATION INJURIES**
chemical protection, 17: 10477(R) (NP-12251)
evaluation of, from blood picture, 17: 10447
in mice, effects of foreign spleen cells on blood and tissue changes in, 17: 10434
in mice, protective effects of isologous bone marrow and leukemoid leukocyte injections against, 17: 10283
of blood vessels, effects of diet, 17: 10485(R) (NP-12251(p.99-113))
protection against, effects of cysteine, propylene glycol, AET, and MEG, 17: 10480(R) (NP-12251(p.22-33))
protection against, evaluation of 46 compounds, 17: 10481(R) (NP-12251(p.34-46))
protection against, effects of cyanides and nitriles in mice, reaction mechanisms, 17: 10482(R) (NP-12251(p.47-66))
protection against, effects of p-aminopropiophenone in mice and rats, 17: 10483(R) (NP-12251(p.67-89))
protection against, 17: 10493
protective effects of injected embryonic tissues in mice, 17: 10421

protective effects of injected lymph cells in mice, 17: 10289
protective effects of β-mercaptoethylamine and anoxia in *Escherichia coli*, 17: 10426
therapy of acute dermatitis using pancreas extract, 17: 10490
**RADIATION MONITORING**
France, October 1962, 17: 10865 (SCPRI(RM) 62-10)
France, September 1962, 17: 10864 (SCPRI(RM) 62-9)
**RADIATION PROTECTION**
design of apron for, to gonads, 17: 10873
dosimetric control and shielding, 17: 10879
procedures for handling serious radiation accidents, 17: 10855 (HW-SA-2609)
procedures used in contaminated glove box disassembly, 17: 10866 (TID-16203)
regulations of the Soviet Union, 17: 10870(T) (JPRS-16995)
training programs, 17: 10854 (HW-SA-2565)
**RADIATION SICKNESS**
effects of hole size in sieve irradiation on, 17: 10497
effects of, on maturation and proliferation of bone marrow cells in animals, 17: 10495
protection against, using Tanderil, 17: 10472
protection against nausea and vomiting in, by meclizine and pyridoxine, 17: 10489
**RADIATION SOURCES**
determination of individual activities in mixed, from decay data, 17: 10547
evaluation of iodine-125 as, for radiopulmonogram, 17: 10280
**RADIATION TARGETS**
performance of deuterium- or tritium-saturated zirconium, 17: 11817
preparation for radioisotope production, 17: 10676 (NP-12231)
sizing of, for x ray sources, 17: 11353
**RADIO WAVES**
effects of centimeter bands of, on sorptive activity of intestine and stomach in dogs, 17: 10315
**RADIOACTIVE CONTAMINATION**
of hands, design of alpha and beta monitor for monitoring of, 17: 10962
of human body (internal), apparatus for measurement of, 17: 10963
**RADIOACTIVE MATERIALS**
handling of, design of shipping container for, 17: 10862 (RFP-290)
**RADIOACTIVITY**
detection and measurement on two-dimensional paper chromatograms, design of semiautomatic device for, 17: 10543
detection and measurement of, design of adiabatic microcalorimeter with automatic control for, 17: 11023
distribution in boiling reactor after fuel failure, loop studies, 17: 11959 (TID-15779)
monitoring in ground water in Hanford Area, 17: 10822 (HW-SA-2566)
**RADIOAUTOGRAPHY**
methods in metallurgy, 17: 11208
of interior surfaces of pipes, 17: 11004 (HW-SA-2651)
technique for electron microscopy, of tritium-labeled biological materials, 17: 10284
**RADIOBIOLOGY**
applications of culture of embryonic organs, 17: 10407
chemical protection against radiation injuries, 17: 10477(R) (NP-12251)
**RADIOCHEMICAL PROCESSING PLANTS**
decontamination of, at Marcoule, 17: 10761
**RADIOCHEMISTRY**
of elastomers, 17: 10691
**RADIODERMATITIS**
pathology and treatment, 17: 10494
therapy using pancreas extract, 17: 10490
**RADIODIAGNOSIS**
beam delineation in x-ray, circular and elliptical, 17: 10273
of lung ventilation impairment, use of iodine-125 radiopulmonogram, 17: 10280
**RADIOFREQUENCY GENERATORS**
loading studies for linear electron accelerators, 17: 11798(R) (TID-17221)
**RADIOFREQUENCY SPECTROMETERS**
design for electron pammagnetic resonance, review, 17: 10929
design range, 17: 10931
**RADIOGRAPHY**
contrast intensification by film copying, 17: 10891 (ANL-FGF-339)
diagnostic, effects of, on chromosones in blood cells and bone marrow in infant, 17: 10435
gamma sources for, 17: 10818
neutron, comparison with other methods, 17: 10814 (ANL-FGF-335)
of coronary arteries by single exposure, method for obtaining, 17: 10267
properties of cesium-137 in, 17: 10817
testing of polaroid camera for neutron, 17: 10999 (ANL-FGF-340)
**RADIOISOTOPES**
calibration of, procedures and instrumentation used by CNEA in, 17: 10677 (NP-12235)
diffusion of gaseous, from minerals, 17: 10829
distribution in nature, 17: 10841
handling and use, ordinance for control and safeguards in, 17: 10857 (NP-12427)
industrial applications of, review, 17: 10977
production and uses of short-lived, review on, 17: 10253
production in synchrotrons, advantages and disadvantages of, 17: 10676 (NP-12231)
separation of daughters from parents, review of milking systems for, 17: 11050 (BNL-6697)
use in thickness measurements, 17: 10978
use of, in measuring flow velocities in surface and underground waters in Bavaria, 17: 10885
use of, in measuring relative flow velocity in ground waters, 17: 10886
uses in national economy in USSR, 17: 10888
uses in physical chemistry, 17: 10643
uses in sugar industry, 17: 10887
uses of, in microbiology, and food industry and research, 17: 10882
**RADIOMETERS**
design of pulsed, 17: 11834(R) (NP-12367)
**RADIOMETRIC ANALYSIS**
of beta-emitting solutions of formamide, 17: 10526 (ANL-6637(p.29-31))
**RADIOSENSITIVITY**
of hematopoietic system in adult and newborn rats, 17: 10368
of mice under mild hypothermia, 17: 10438
of *Pseudomonas aeruginosa*, effects of oxygen concentration, 17: 10419
**RADIOSTERILIZATION**
of blood vessels, effects on hetero- and homotransplantation of, 17: 10450
of diet, effects on cytochrome oxidase and growth of successive rat generations, 17: 10350
of disposable hypodermic syringes, commercial plant for, 17: 10266
of meat, effects of low temperatures on *Clostridium botulinum* spores, 17: 10883
research in, at Danish accelerator facility, 17: 11812
**RADIOTHERAPY**
dosimetry of vaginal smear in, 17: 10259
effects on esophagitis in man, 17: 10269
effects on leukocyte motility in man, 17: 10445
effects on nephritis in man, 17: 10440
effects on thyroid gland cancer in children, 17: 10262
of carcinoma of cervix, complication in, from supervoltage and telecobalt, 17: 10449
of carcinoma of uterine cervix, complications from, 17: 10496
of cerebral astrocytomata in man, effects of whole-body hypothermia on, 17: 10438
of gastric tumors and peptic ulcers, effectiveness of intragastric irradiation using beta source, 17: 10367 (TID-17727)
of gynecological carcinomas, late effects from, 17: 10372
of malignant tumors in man, effects of adrenal steroid therapy on symptoms from, 17: 10268
use of microspheres containing scandium-46 and yttrium-90 for, in animals and man, 17: 10288
**RADIUM**
distribution and retention in skeleton in man, 17: 10309 (TID-17644)
distribution of injected, in tissues in man, whole-body counting, 17: 10300(R) (COO-226(p.71-77))
dosage measurements in bone, 17: 10302(R) (COO-226(p.86-94))
maximum permissible deposition dose in man, 17: 10337
**RADIUM ISOTOPES**

toxic effects in dogs, 17: 10294(R) (COO-226)
**RADIUM ISOTOPES Ra-226**
content in diet in U. S., 17: 10530 (ANL-6637(p.85-95))
detection and measurement of activity of, design of microcalorimeter for, 17: 11023
determination in biological samples, radiochemical, 17: 10529 (ANL-6637(p.59-84))
determination in soil, 17: 10531 (ANL-6637(p.97-9))
determination, radiometric, 17: 10530 (ANL-6637(p.85-95))
dosage determinations in tissue, 17: 10301(R) (COO-226(p.78-85))
effects of environmental contamination on intake by man, 17: 10529 (ANL-6637(p.59-84))
hematological effects of injected, in dogs, 17: 10297(R) (COO-226(p.50-6))
pathological effects of injected, in dogs, 17: 10296(R) (COO-226(p.35-49))
toxicity in dogs, 17: 10295(R) (COO-226(p.3-33))
**RADIUM ISOTOPES Ra-228**
content in skeleton, correlation with injection of thorotrast, 17: 10351
pathological effects of injected, in dogs, 17: 10296(R) (COO-226(p.35-49))
toxicity in dogs, 17: 10295(R) (COO-226(p.3-33))
**RADON ISOTOPES Rn-218**
alpha half life of, 17: 11632 (TID-16202)
**RADON ISOTOPES Rn-222**
diffusion from alkali metal chloride crystals during thermal annealing, 17: 10638
**RAIN WATER**
drop sampler, 17: 10848(R) (HW-73337(p.1-28))
radiation monitoring in France during September 1962, 17: 10864 (SCPRI(RM)62-9)
radiation monitoring in France during October 1962, 17: 10865 (SCPRI (RM)62-10)
raindrop spectra, 17: 10848(R) (HW-73337(p.1-28))
tritium content in Cologne in 1960–61, 17: 10840
**RARE EARTH ALLOYS**
electric conductivity at 4.2°K, residual, 17: 11367
hardness of, survey, 17: 11186 (DRI-2080)
**RARE EARTH CARBIDES**
hydrolysis, 17: 10591 (IS-499)
**RARE EARTH CHLORIDES**
radiolysis effects on yields in liquid methanol, 17: 10699
**RARE EARTH COMPLEXES**
formation from rare earth nitrilotriacetate reactions with potassium hydroxide, 17: 10501 (IS-458)
nitrilotriacetate, reactions with potassium hydroxide at 25°C, 17: 10501 (IS-458)
**RARE EARTH COMPOUNDS**
ion energy levels in cubic-symmetry sites in, 17: 10636
**RARE EARTH HALIDES**
electron exchange in molten divalent and trivalent mixtures of, 17: 10513(R) (ORNL-3320(p.98-103))
heat of fusion, 17: 10513(R) (ORNL-3320(p.98-103))
**RARE EARTH IONS**
energy levels in cubic crystal fields, 17: 10636
fluorescence spectra by x radiation, 17: 11368
fluoresecent lifetime effects on terbium, 17: 10626
**RARE EARTH ISOTOPES**
determination in mixed fission products, radiochemical, 17: 10850(R) (HW-73337(p.77-157))
**RARE EARTH OXIDES**
analysis for europium, 17: 10572
**RARE EARTHS**
adsorption of lanthanides by inorganic ion exchange materials, 17: 10740(R) (ORNL-TM-181)
discovery and development of, review on, 17: 10618
distribution in meteorites, 17: 10821(R) (GA-2985)
distribution in tissues in mammals, tracer study, 17: 10324
electric conductivity of, effects of screw-spin ordering on, 17: 11413
electric conductivity of rare earth trichloride solutions of, 17: 10513(R) (ORNL-3320(p.98-103))
reactions with polonium at high temperatures, 17: 10239(R) (MLM-1140)
separation by leaching and solvent extraction, 17: 10764
separation of lanthanides from actinides by liquid-gel extraction using amines, 17: 10740(R) (ORNL-TM-181)
separation of trivalent, from calcium, magnesium, nickel, and strontium by cation exchange, 17: 10734 (IS-508)
solvent extraction from purex wastes, flowsheet for, 17: 10740(R) (ORNL-TM-181)
**RARE GASES**
production of, application of gas chromatography, 17: 10954
**RATE METERS**
circuits for transistorized, 17: 10960
design and operation of transistorized, 17: 10959
design and performance of slow neutron dosimeters, 17: 11034
**RATS**
americium metabolism, tracer study, 17: 10325
calcium and strontium in blood serum and bones in mechanism of parathyroid hormone effects on, 17: 10264
leukemia induced in, transmission of, 17: 10258
movement of food in small intestine in, tracer study using yttrium-91, 17: 10281
plutonium deposition in bones of rachitic, tracer study, 17: 10330
plutonium metabolism, tracer study, 17: 10325
radiation effects on fixated behavior and maze performance in, cranial, 17: 10430
radiation effects on islet-cell tumors in pancreas in, 17: 10432
radiation effects on survival of, effects of isogenic bone marrow and lymphocyte injections on, 17: 10437
radiation effects on brain of, gamma and x, 17: 10459
radiation effects on Purkinje cells in, 17: 10460
radiation effects on neurons in, 17: 10461
radiation effects on urinary excretion of potassium and sodium by, x, 17: 10463
radiation effects on connective tissue collagen, 17: 10465
radiation effects on DNA and RNA in neurons of cerebellum and Gasser ganglion of, 17: 10466
radiation effects on, relation of hole size in sieve irradiation to, 17: 10497
radiation effects on prepyriform electrical activity in, whole-body, 17: 10373
radiation effects on bone marrow in, whole-body gamma, 17: 10413
radiation effects on survival of, effects of surgical isolation of intestinal segment on, 17: 10378
radiation injury to kidneys and submaxillary gland, effects of cortisone on, 17: 10470
radiation lethality in, from morning and night exposures, 17: 10467
radiation lethality in, effects of cysteamine on, 17: 10488
radiation sickness of, effects of, on maturation and proliferation of bone marrow in, 17: 10495
radioinduced pneumonitis in, 17: 10377
radiosensitivity of hematopoietic system in adult and newborn, 17: 10368
radiosterilized diet effects on cytochrome oxidase activity and growth in successive generations of, 17: 10350
strontium content of blood and bones of, age and sex dependence of, 17: 10347
strontium metabolism in bones of, effects of testosterone on, 17: 10348
toxicity of plutonium in, synergistic effects of x radiation, 17: 10318
uranium injury effects on fine structure of kidney tubules in, 17: 10265
zinc distribution and turnover in, tracer study, 17: 10275
**REACTION MECHANISMS**
analysis of, computer programs for, 17: 10606 (UCRL-7069)
anodic oxidation, 17: 11138
Gibbs statistics for ideal and real gaseous systems of isotopes, 17: 10655
induced by nuclear processes and radiations, review, 17: 10720
kinetic analysis of consecutive reaction model systems, 17: 10610 (UCRL-10575)
kinetics of fast interfacial reactions, analysis, 17: 10601 (TID-15942)
photochemical, effects of disulfides and mercaptans on, 17: 10680(R) (TID-17584)
**REACTOR COMPONENTS**
decontamination of, development of processes for, 17: 12042 (MSAR-61-34)

**REACTOR CONTROL ELEMENTS**
development of, review of technical progress on, 17: 11123
**REACTOR CONTROL RODS**
calibration of, development of digital method for, 17: 11964 (TID-17815)
materials development for, technical progress review, 17: 11128
materials for, preparation, radiation effects, and stability of boron carbide–graphite as, 17: 11085 (GA-3064)
neutron angular distributions at the surface of, 17: 11303(R) (HW-75228)
worths of black and gray, 17: 12029
**REACTOR CONTROL SYSTEMS**
circuits for, transistor, 17: 10989
design and stability of negative-feedback, 17: 12004
design of burst fuel element detection systems, 17: 10991
design of, for gas-cooled reactors, effects of stability studies on, 17: 10984
design of fuel temperature scanner, 17: 10992
development for gas-cooled reactors, 17: 10994
instrument maintenance procedures and problems at Calder Hall, 17: 10997
instrumentation for gas-cooled reactors, review of, 17: 10995
instrumentation for water-cooled, review, 17: 10996
neutron absorption measurement by poison in, 17: 11629 (TID-15884)
period meter for, design of pulse-counting direct-reading, 17: 10973
theory and design for gas-cooled reactors, 17: 10983
**REACTOR COOLANTS**
critical heat fluxes for polyphenyls, 17: 10800 (NAA-SR-7954)
evaluation of steam–water spray, development of apparatus for, 17: 11942(R) (EURAEC-476)
evaluation of steam–water spray, 17: 11941(R) (EURAEC-475)
mechanism of heat transfer in wet steam, 17: 11965 (UNC-5008-I)
purification of gaseous, 17: 10743(R) (ORNL-TM-457)
radiation effects on organic, 17: 11268(R) (TID-16999)
survey of gaseous, 17: 10516 (ORNL-TM-475)
**REACTOR ENGINEERING**
computer program for three-region fully reflected cylindrical reactors, 17: 11933 (AAEC/E-101)
development of Hanford data logging systems, 17: 11946 (HW-SA-2549)
heat transfer and stability in boiling systems, 17: 11980(R) (EURAEC-414)
neutron flux simulation using a diffusion code, 17: 11599 (WAPD-T-1457)
pile oscillator determination of capture-to-fission ratios, 17: 11963 (TID-17738)
**REACTOR FUEL ELEMENTS**
cladding of, review of developments on, 17: 11123
cleaning of OMRE, by ultrasonics, 17: 11954(R) (NYO-10284)
coolant flow mixing in rod bundle, 17: 10804 (WCAP-1607)
cooling of PRTR, by transverse air flow, 17: 10793 (HW-72097(Rev.))
development and fabrication of improved uranium-base, 17: 11095(R) (NMI-7254)
dimensions of, design of device for recording, 17: 10893 (HW-75746)
fabrication and performance of cylindrical, 17: 11259 (HW-71521(Rev.))
fabrication of composite thorium oxide–uranium oxide, 17: 11111(T,R) (EURAEC-407)
fabrication of high-power-density, development of improved methods for, 17: 11945(R) (GEAP-4096)
fabrication of packed-powder, 17: 11143 (CEND-153(Vol.I)(p.11-21))
fabrication of powder-packed uranium dioxide, conference on, Windsor, Conn., Nov. 30 and Dec. 1, 1961, Vol. II, 17: 11153 (CEND-153 (Vol.II))
fabrication of sheathed uranium dioxide by powder compaction, review, 17: 12013
fabrication of uranium dioxide powder-packed, conference on, Windsor, Conn., Nov. 30 to Dec. 1, 1961, Vol. I., 17: 11141 (CEND-153(Vol.I))
fabrication of uranium dioxide powder-packed, economic evaluation of methods for, 17: 11142 (CEND-153(Vol.1)(p.3-10))
fabrication of Zircaloy-clad uranium oxide, 17: 11979(R) (DP-805)
failure in reactors, design of detection system for, 17: 10991
failure in reactors, bibliography on, 17: 11956 (TID-3573)
fission product release from gas-cooled, 17: 11944 (GAMD-3378)
neutron flux distribution in heavy water lattices of simulated CANDU and NPD, 17: 11939 (CRL-75)
permeability of HTGR-type, effects of helium stream in-sweeping on, 17: 11189 (GAMD-2638)
processing of irradiated uranium carbide, 17: 10736 (NAA-SR-7511)
processing of irradiated, use of dibutyl ether in, 17: 10755
processing of, leach-shear development, 17: 10743(R) (ORNL-TM-457)
reactivity of composite thorium oxide–uranium oxide, 17: 11111(T,R) (EURAEC-407)
sampling apparatus for cylindrical graphite specimens from irradiated, 17: 11934 (AERE-R-3453)
separation of uranium from unirradiated, by fluoride volatility, 17: 10728 (BNL-6148)
shearing of irradiated clad uranium dioxide, quality of fines produced in, 17: 10246(R) (ORNL-TM-403)
testing of glass-base, 17: 11102(R) (NYO-9735)
testing of plutonium-base, research program, 17: 10249(T,R) (EURAEC-301)
x-ray-diffraction analysis of irradiated, design of unit for, 17: 10894 (HW-SA-2616)
**REACTOR FUEL ELEMENTS (CERAMIC)**
bonding to metal, 17: 11311(R) (LAMS-2796)
fabrication and irradiation testing, 17: 11110(T,R) (EURAEC-387)
fabrication and reactivity, 17: 11109(T,R) (EURAEC-338)
fabrication of, 17: 11114(T,R) (EURAEC-477)
fabrication of plutonium oxide–uranium oxide, research program, 17: 11108(T,R) (EURAEC-307)
fabrication of plutonium carbide–uranium carbide, research program, 17: 11108(T,R) (EURAEC-307)
processing by fluoride volatility, 17: 10744 (TID-13765)
processing carbide and oxide, 17: 10737 (NBL-189)
radiation effects on carbide, 17: 11114(T,R) (EURAEC-477)
radiation effects, 17: 11270 (WAPD-T-1455)
radiation effects on, apparatus and procedure for testing, 17: 11271(T,R) (EURAEC-410)
thermal behavior of composite, 17: 11967(T,R) (EURAEC-499)
**REACTOR FUEL ELEMENTS (DISPERSION)**
development of, technical progress review, 17: 11126
fabrication and testing for Borax-V, 17: 11078 (ANL-FGF-329)
fabrication of plutonium oxide and carbide dispersed in metallic matrix, research program, 17: 11108(T,R) (EURAEC-307)
**REACTOR FUEL ELEMENTS (IMPREGNATED)**
radiation effects at 1500°C to 10% burnup, 17: 11261 (LAMS-2814)
**REACTOR FUEL ELEMENTS (THERMOELECTRIC)**
development, 17: 11313(R) (MND-2945-1)
**REACTOR FUEL PLATES**
design and construction of, composed of uranium oxide in polyethylene dispersion, 17: 12027
**REACTOR FUEL RODS**
criticality and exponential studies of water-moderated, 17: 11938 (BAW-1257)
fission product buildup in, measurements on uranium dioxide-filled, 17: 11086(R) (GEAP-3771-4)
performance of compacted-powder uranium-dioxide, 17: 11156 (CEND-153 (Vol.II)(p.67-76))
radiation effects on microstructure of uranium dioxide, 17: 11260 (HW-SA-2650)
spectral and fine structure measurements in uranium–heavy water and uranium–water, 17: 11940 (CRRP-895)
**REACTOR FUEL TUBES**
brazing, 17: 11095(R) (NMI-7254)
radiation effects on, methods of measuring, 17: 11259 (HW-71521(Rev.))
**REACTOR FUELS**
analysis for boron and plutonium, 17: 11303(R) (HW-75228)
burnup of, effects on heat transfer, 17: 11969
development at Riso, 17: 11121
development of coated-particle, 17: 11126
development of, review of technical progress on, 17: 11123
heat transfer from irradiated, 17: 10743(R) (ORNL-TM-457)
isotopic composition of irradiated, effects on refabrication and reprocessing, 17: 11253 (BLG-140)
neutron absorption measurement, 17: 11629 (TID-15884)
processing of, leach and shear developments for, 17: 10741(R) (ORNL-TM-313)
production of, 17: 10724

production of graphite-coated particles by fluidized bed process, 17: 11174
radiation effects, 17: 11126
radiation effects, bibliography, 17: 11269 (VDIT-16(2.4))
reprocessing in fluidized beds, 17: 10730 (BNL-6195)
reprocessing of spent, 17: 10519(T,R) (EURAEC-460)

**REACTOR MATERIALS**
development, 17: 11935(R) (ANL-6658)
development of cladding and structural, review of technical progress on, 17: 11123
development of, review, 17: 11124
radiation effects on ceramic, 17: 11125
radioinduced heating, 17: 11619 (CEA-2172)
review, 17: 12014

**REACTOR MATRICES**
criticality studies of water-moderated thorium dioxide and uranium dioxide, 17: 11938 (BAW-1257)
eigenvalue matrix solution to N-component neutron interaction problems in arrays of neutron emitters, 17: 11458 (HW-75887)
neutron rethermalization in heavy water cooled and moderated uranium and uranium oxide, 17: 11962 (TID-17574)
spectral and fine structure measurements in uranium–heavy water and uranium–water, 17: 11940 (CRRP-895)

**REACTOR MODERATORS**
development of, review of technical progress on, 17: 11123
neutron slowing-down in, renewal theory for, 17: 11603
neutron thermalization parameters of, 17: 11605
theory of neutron transport in finite, time-dependent solutions of, 17: 11597 (TID-16085)

**REACTOR SAFETY**
containment analyses, 17: 11937(R) (ARF-4132-16)
description of Ravenswood reactor plant for hazards summary report, 17: 10858 (NP-12466(Vol.I))
design of burst fuel element detection systems, 17: 10991
design of fuel temperature scanner, 17: 10992
developments in, 17: 11936(R) (ANL-6672)
drawings for Ravenswood hazards summary report, 17: 10860 (NP-12466 (Vol.III))
hazards summary for Ravenswood, preliminary report, 17: 10859 (NP-12466(Vol.II))
hazards summary on Northrop Reactor, 17: 12025 (NP-12299)
site data for Ravenswood, 17: 10861 (NP-12467)

**REACTOR SAFETY EXPERIMENTS**
development, 17: 11935(R) (ANL-6658)
radiolytic gas production in, analysis of conditions for, 17: 11952 (NAA-SR-7086)

**REACTOR SHIELDING**
design for ANP Reactor (SCW), 17: 11988 (PWAC-100)
design for power production, 17: 12039
gamma transport in, spherical harmonics technique for, 17: 11502 (WAPD-T-1458)

**REACTOR SIMULATORS**
design of circuit for prediction of xenon buildup, 17: 10993
testing of model for Frankfurt Research Reactor, 17: 12024 (IKF-3)
use in analysis of steam-cooled liquid-moderated maritime reactors, 17: 10985

**REACTOR SLURRIES**
development of uranium dioxide in potassium–sodium alloy, 17: 11077 (ANL-6644)

**REACTORS**
containment of, 17: 11937(R) (ARF-4132-16)
control and instrumentation system dynamics, statistical methods for calculating, 17: 11947 (HW-SA-2558)
critical mass calculation for cylindrical, in case of anisotropic diffusion coefficient, 17: 11463
development in United States, handbook on constructed and planned reactors, 17: 11957 (TID-8200(7th Rev.))
geographical distribution of, 1963, 17: 11971
heat-transfer analysis of, computer program for, 17: 10795 (IDO-28595)
hot spot calculations for, statistical methods of, 17: 11943(R) (EURAEC-500)
instrumentation for, use of magnetic amplifier in, 17: 10990
kinetics of, effects of delayed neutrons on shape of distribution curve in, 17: 11949 (IFK-2)
neutron spectra of, measurement, 17: 11594 (SCTM-205-62(53))
physics constants, review, 17: 12011
physics of, generalized variational methods for, 17: 11972
power distribution, computer program for calculating axial, 17: 11951 (KAPL-M-RPC-5)
power of, design of thermocouples for in-core monitoring to 1800°F, 17: 10940
reactivity calculation, computer program for excess, 17: 11950 (KAPL-M-EC-28)
startup of, kinetics of low-source, 17: 11961 (TID-16142(Pt.II))
startup with weak source, analysis of statistical fluctuations in, 17: 11960 (TID-16142(Pt.I))
theory of, recent developments in, 17: 11975

**REFRACTION**
amplitudes of refraction arrivals, method for calculation of, 17: 11337 (UCRL-7146)

**REFRACTORY MATERIALS**
bibliography, 17: 11100 (NP-12493)
development for use in high-temperature dies, 17: 11081(R) (ASD-TR-7-886(Vol.VII))
development of, for use in rocket motors, 17: 11076 (AD-278371)
properties of, summary of, 17: 11119(T) (JPRS-17322)
thermionic emission by cesium-coated, 17: 11347

**RELATIVITY THEORY**
asymptotic properties of fields and space-times in, 17: 11401
conformal transformations of space and time, physical significance and representation of, 17: 11345
frontiers with differential geometry, 17: 11930
positive-definite energy density and global consequences for general, 17: 11918
quantum field theory in agreement with, 17: 11926

**REMOTE-CONTROL EQUIPMENT**
development of master-slave, 17: 10787
development of master-slave manipulator, 17: 11936(R) (ANL-6672)

**RENÉ-41**
brazing and welding of, criteria for, 17: 11163 (DMIC-181)
radiation effects on tensile properties, 17: 11087(R) (GEMP-19A)
radiation effects on mechanical properties, 17: 11129

**RESEARCH REACTORS**
corrosion problems in Canada–India, 17: 11136
design of light water-cooled and -moderated Consort II for London University, 17: 12028
dynamics of Frankfurt Research Reactor, testing of model for, 17: 12024 (IKF-3)
equipment for, for producing cold neutrons, 17: 12032
fuel elements for Siemens, 17: 12027
hazards analysis for second Polish, 17: 11973
neutron flux distribution measurements in experimental parts of Frankfurt Research Reactor, 17: 12023 (IKF-1)
safety of, final report on Northrop, 17: 12025 (NP-12299)
use of Nordrhein-Westfalen, for medical purposes, 17: 12026

**RESINS**
epoxy, reactor radiation energy deposition in polymerized, 17: 11280
radiation effects on stability of, effects of charge and radius of hydrated exchange ion on, 17: 10719
thermodynamic potential of ion exchange, effects of swelling on, 17: 11252

**RESISTANCE THERMOMETERS**
radiation effects on, thermal neutron, 17: 11273

**RESISTORS**
design and operation of noninductive high-voltage pulse, 17: 10905 (SCTM-230-62(14))
performance of molybdenum, for long heating periods, 17: 11084(R) (EURAEC-388)

**RETICULO-ENDOTHELIAL SYSTEM**
distribution of thorium-232, thorium-228, and radium-228 after injection of thorotrast, 17: 10351

**RHENIUM**
nuclear quadrupole resonance, 17: 10592 (IS-520)
spectra of, atomic absorption, 17: 10549

thermionic properties of, in cesium vapor, 17: 11346
**RHENIUM ALLOYS**
Mo–Re, hardness, 17: 11094(R) (NMI-2113)
Nb–Re, extrusion, 17: 11093(R) (NMI-2112)
Nb–Re, hardness, 17: 11083(R) (NMI-2112)
Re–Ta, fabrication of, by rolling and swaging, 17: 11094(R) (NMI-2113)
Re–Ta, hardness, 17: 11094(R) (NMI-2113)
Re–Ta–W, hardness, 17: 11094(R) (NMI-2113)
Re–Ta–W, hardness, 17: 11093(R) (NMI-2112)
Re–Zr, phase studies of, 17: 11213
**RHENIUM COMPLEXES**
spectra of hexavalent bromide and chloride, 17: 10507(R) (ORNL-3320 (p.16-21))
**RHENIUM COUPLES**
Re–W, development for temperature measurements in Zircaloy-2 weldments, 17: 11105 (TID-17734)
**RHENIUM ISOTOPES Re-184**
decay of isomers of, 17: 11717
**RHODIUM**
deuteron scattering at 3 to 30 Mev, optical model analysis of, 17: 11676
heat of vaporization, 17: 10240(R) (NP-12208)
proton reactions at 5 to 12 Mev, neutron spectra from, 17: 11631 (TID-16049)
**RHODIUM ALLOYS**
Pt–Rh, thermal conductivity and expansion at 500 to 2500°F, 17: 11199 (UCRL-13061)
**RIBONUCLEASE**
radiation effects on activity of, in barley seedlings, 17: 10456
**RIBONUCLEIC ACID**
radiation effects on metabolism of, in barley seedlings, 17: 10456
radiation effects on behavior of, in neurons of cerebellum and Gasser ganglion of rats, 17: 10466
radiation effects on metabolism in nervous system, 17: 10356 (BNL-6546)
radiation effects on synthesis of, in *Paramecium aurelia*, 17: 10408
radiation effects on restoration of, in amoeba, 17: 10410
**RIBONUCLEIC ACID, DESOXY-**
mutagenic effect of carbon-14- and tritium-labeled precursors of, on *D. melanogaster* males, 17: 10401
radiation effects on metabolism of, in barley seedlings, 17: 10456
radiation effects on behavior of, in neurons of cerebellum and Gasser ganglion of rats, 17: 10466
radiation effects on synthesis of, in *Paramecium aurelia*, 17: 10408
synthesis of, in peripheral blood cells in rabbits, effects of colloidal silver, hemorrhage, and x radiation on, 17: 10291
**ROCKET MOTORS**
development of pyrolytic graphite for use in solid-propellant, 17: 11076 (AD-278371)
survey of fuel for in-type, 17: 11302 (ASD-TR-61-150(Pt.II))
**ROCKET REACTORS**
development of gas-fueled, 17: 12038
dynamics of, analysis of closed-loop, 17: 12037
performance of, effects of using lithium hydride propellants on, 17: 12034 (NP-12353)
**ROCKET REACTORS (TORY)**
design and development, 17: 11990 (UCRL-5484(Del.))
operation of, determination of fission products released in effluents from, 17: 11953 (NARF-61-4SR)
**ROCKETS**
bibliographies on, 17: 11457
**RODS**
heat transfer to air-water systems from arrays of parallel, 17: 10812
heat transfer to flowing liquids from internally heated, 17: 10810
neutron resonance integrals in uranium metal and oxide, 17: 11667
neutron resonance integrals in uranium metal and oxide, 17: 11668
**ROLLING**
techniques for, development of, 17: 11130
**RUBBER**
beta sorption and glass transition in, effects of temperature on, 17: 11282
radiation effects on insulating vulcanizates of silicate-filled, resistance to, 17: 11286
radioinduced chlorination of polydimethylsiloxane, at 0°C, 17: 10715
**RUBIDIUM**
determination in aluminum as trace impurity, activation, 17: 10546
nuclear quadrupole resonance, 17: 10592 (IS-520)
**RUBIDIUM ISOTOPES**
separation from rubidium hydroxide amalgams, 17: 10508(R) (ORNL-3320(p.22-9))
**RUBIDIUM ISOTOPES Rb-86**
beta decay correlations in, 17: 11698
**RUBIES**
excited state lifetime in, measurement of, 17: 10651
**RUTHENIUM ALLOYS**
Pt–Ru, thermal conductivity and expansion at 500 to 2500°F, 17: 11199 (UCRL-13061)
Ru–Ta, extrusion, 17: 11093(R) (NMI-2112)
Ru–Ta, fabrication of, by rolling and swaging, 17: 11094(R) (NMI-2113)
Ru–Ta, hardness, 17: 11093(R) (NMI-2112)
Ru–W, extrusion, 17: 11093(R) (NMI-2112)
Ru–W, hardness, 17: 11093(R) (NMI-2112)
**RUTHENIUM ISOTOPES Ru-106**
removal of internally deposited, evaluation of chelating agents, 17: 10333
**RUTILES**
adsorptive properties for benzene and n-dodecane drops under dodecyl ammonium chloride-water solutions, effects of hysteresis angles on, 17: 11091(R) (MITS-49)

# S

**SAFETY**
criticality control, 17: 10528 (ANL-6637(p.43-57))
in handling zirconium and its alloys, 17: 10863 (RSPP-20(Issue 1))
ordinance on control of radioisotopes and safeguards against radiation hazards, 17: 10857 (NP-12427)
status of meteorological knowledge as factor in pollution control, 17: 10843 (BNL-6538)
survey of radiation facilities and hygiene in dental offices, 17: 10871
training programs, 17: 10854 (HW-SA-2565)
**SALIVARY GLANDS**
radiation damage to, in rats, effects of cortisone on, 17: 10470
radioinduced chromosome breakage in, in Drosophila, 17: 10403
**SAMARIUM**
determination in aluminum as trace impurity, activation, 17: 10546
distribution in tissues of mice of ionic and chelated form, tracer study, 17: 10308 (TID-17542)
neutron effective cutoff energies, 17: 10506(R) (ORNL-3320(p.1-15))
**SAMARIUM ARSENIDES**
thermoelectric properties, 17: 11296 (AD-278352)
**SAMARIUM ISOTOPES Sm-150**
neutron cross sections and resonance integrals, 17: 10506(R) (ORNL-3320(p.1-15))
**SAMARIUM ISOTOPES Sm-151**
energy levels in, 17: 11652
**SAMARIUM ISOTOPES Sm-152**
gamma decay, angular distribution coefficients, 17: 11647 (UCRL-10202)
**SAMARIUM OXIDES**
separation from europium, polarographic, 17: 10572
**SAMARIUM SELENIDES**
thermoelectric properties of sesqui-, 17: 11292 (AD-277043)
thermoelectric properties, 17: 11296 (AD-278352)
**SAMPLING**
of fallout, development of electrostatic precipitator for, 17: 10856 (NP-12351)
**SANDS**
fluidization of, effects of electrostatic phenomena on, 17: 11202(T) (AEC-tr-5621)
**SATELLITES**
bibliographies on, 17: 11457
electron density, magnetic field, and spread echoes from Alouette, 17: 11451
electron density perturbation by Alouette, local, 17: 11451
mass spectrometer for use in, 17: 10945
**SAVANNAH RIVER COMPONENTS TEST REACTOR**

operation in Nov. 1962, 17: 11979(R) (DP-805)
research program, 17: 11097(R) (NMI-7257)
**SCALERS**
development of magnetic memory, 17: 10968
**SCANDIUM**
determination in aluminum as trace impurity, activation, 17: 10546
discovery and development of, review on, 17: 10618
distribution in tissues of mice of ionic and chelated form, tracer study, 17: 10308 (TID-17542)
spectra of, atomic absorption, 17: 10549
**SCANDIUM ALLOYS**
Sc–Tc, phase studies on, 17: 11220
**SCANDIUM ISOTOPES Sc-44**
gyromagnetic factor of first excited state, 17: 11612 (AFOSR-2975)
**SCANDIUM ISOTOPES Sc-45**
alpha reactions in, excitation functions and cross sections for, 17: 11624 (NYO-10386)
**SCANDIUM ISOTOPES Sc-46**
determination in water, radiochemical, 17: 10850(R) (HW-73337(p.77-157))
use of, in microspheres for cancer therapy in animals and man, 17: 10288
**SCANDIUM VANADATES**
structure of, x ray diffraction analysis of, 17: 10663
**SCATTERING**
amplitudes for charged particles, analytic properties of, 17: 11572
amplitudes for vector mesons, 17: 11509
amplitudes in, Regge trajectory and resonant partial wave, 17: 11530
amplitudes of, complex angular momentum plane of, 17: 11495 (TID-17731)
amplitudes of, for spin-½-particle–field interactions, 17: 11508
amplitudes, unitarity and behavior of, 17: 11912
analytic properties of the S-matrix in, Mandestam's work on, 17: 11483 (NP-12436)
angular momentum poles of S matrix for spin ½ particles, 17: 11913
angular momentum poles for, S matrix representations of, 17: 11914
angular momentum transport in quantum statistical mechanics of, 17: 11917
bounds on momentum dependence of phase shifts and magnitude of coupling constants, 17: 11922
complex angular momentum in many-channel potential, 17: 11501 (UCRL-10209)
electrodynamics of, method for writing quantum, 17: 11468 (JINR-D-1108)
many-body problems in, 17: 11481 (NP-12435(Pt.I))
many-body problems in, 17: 11482 (NP-12435(Pt.II))
mathematics of multiple, discussion of uniqueness problems in, 17: 11490 (RM-3221-PR)
operator for gases, three-particle, 17: 11513
particle model of, from collective states of nuclei, 17: 11699
phase shifts in spin-½–spin-0 elastic, 17: 11570
phenomenological analysis of high-energy, 17: 11566
quantum mechanical relations for, 17: 11932
Regge pole trajectory for elastic, removal of the meaningless state on vaccum, 17: 11486 (NP-12479)
Regge poles and perturbation theory in, 17: 11905 (JINR-E-1095)
Regge trajectory in field theory, 17: 11919
relativistic theory of, complex angular momentum in, 17: 11521
semi-classical approach to high-energy, 17: 11925
simulation of the hard core by a velocity dependence, 17: 11921
solution of kinetic equations in, application of the stationary phase method in, 17: 11308 (JINR-P-1113)
strength of coupling constant in strong interactions, 17: 11924
theory of, hypervirial theorem in, 17: 11908
theory of, hypervirial theorem in, 17: 11909
theory of multiple small-angle, relativistic correction to, 17: 11573
theory of, new approximation in, 17: 11492 (TID-16044)
theory of nucleon, strip approximation to Mandelstam, 17: 11498 (UCRL-10028)
theory of radiation damping, 17: 11916
theory of S-matrix, 17: 10240(R) (NP-12208)
trajectories in, two Pomeranchuk-Regge, 17: 11915
velocity-dependent nucleon–nucleon Green potential in, 17: 11527
**SCINTILLATION DETECTORS**
design and performance of, review, 17: 10964
design and performance of glass, 17: 10965
design of, for counting carbon-14 and tritium in gas-liquid chromatographic effluents, 17: 11027
development of cerium-activated glass, for alpha counting, 17: 11003 (HW-72512)
gamma resolution of, energy dependence of, 17: 11627 (TID-15088)
image contrast intensification for, 17: 11046
performance in nonosecond range, spark pulse generators in improving, 17: 11037
performance of gas, 17: 11005 (IKF-5)
performance of, statistical analysis of, 17: 11041
performance of, with calcium fluoride crystals, 17: 11044
use of liquid, for absolute activity measurements, 17: 10966
voltage supply for, design of stable high, 17: 11022
**SEA WATER**
strontium-90 content in surface, 17: 10835
**SEALS AND GLANDS**
development of, for high-pressure pumps, 17: 10778(R) (NYO-9742)
development of, for high-pressure pumps, 17: 10779(R) (NYO-9743)
**SEED**
radiation effects on maize, neutron and x, 17: 10380
radiation effects on electron spin resonance signals, 17: 10850(R) (HW-73337(p.77-157))
radioinduced mutations in *Vicia sativa* L, 17: 10395
**SEEDLINGS**
radiation effects on nucleic acid and protein metabolism in barley, 17: 10456
radiation effects on cell division, 17: 10359 (HW-SA-2606)
**SEIGNETTOELECTRIC MATERIALS**
Mössbauer effect in, relation to homogeneous modes of lattice vibrations, 17: 10639
**SEISMOLOGY**
aftershock measurements in CIMARRON event, 17: 10242 (NP-12339)
data for amplitudes and travel times from STILLWATER event, 17: 10244 (NP-12444)
data for on-site inspection, Vela Project, 17: 10238(R) (AD-278378)
long-range measurements of Dormouse prime shot, 17: 11321 (NP-12418)
long-range seismic measurements of New Madrid, event on Feb. 2, 1962, 17: 10825 (NP-12465)
seismograms compilation for Project GNOME, 17: 10824 (NP-12462)
**SELENIUM**
displacement in zinc selenides by electron bombardment, 17: 11320 (NP-12360)
**SELENIUM ISOTOPES**
separation by thermodiffusion concentration distribution in tubes for, 17: 11059
**SELENIUM ISOTOPES Se-76**
energy levels in, structure of low-lying $2^+$, 17: 11698
**SEMICONDUCTOR DETECTORS**
characteristics and response, 17: 11045
characteristics of, review, 17: 11009 (TID-16206)
design for flux mapping in inaccessible reactor core regions, 17: 10988
development for monitoring air for plutonium, 17: 11012 (UCRL-6692)
development of cadmium sulfide, 17: 11006 (NP-12376)
development of, for use at cryogenic temperatures, 17: 10900(R) (NP-12363)
performance, for alpha energy measurements, 17: 10850(R) (HW-73337 (p.77-157))
review, 17: 10957
use in health physics monitoring instruments, 17: 10960
**SEMICONDUCTORS**
noise generation in, low-frequency, 17: 10936
production of silicon p-n junctions by ion bombardment, 17: 10773 (ASD-TDR-62-428)
properties of narrow-band, as thermoelectric elements, 17: 11294(R) (AD-277223)
radiation effects, 17: 11267 (TID-15959)
research program on wires and solenoids, 17: 11335 (TID-17827)
thermoelectric effects in non-linear junctions of, 17: 11294(R) (AD-277223)
use in circuits for nuclear instrumentation, 17: 10957

**SEPARATION PROCESSES**
development, 17: 11936(R) (ANL-6672)
for metals, by cation exchange, 17: 10733 (IS-466)
**SHEEP**
transfer to transuranic elements from plasma to milk, tracer study, 17: 10326
**SHELTERS**
development of blast-closure valve for ventilation systems, 17: 10776 (NP-12454)
**SHIELDED CONTAINERS**
construction of low-background counting facility, evaluation of Portland cements for use in, 17: 11903 (UCRL-10475)
design for plutonium shipping, 17: 10862 (RFP-290)
structural integrity in transport, research program for evaluation of, 17: 10780 (NYO-9859)
**SHIELDING**
evaluation of, for interelectrode space in plasma cells, 17: 11311(R) (LAMS-2796)
**SHIELDING MATERIALS**
neutron attenuation by, 17: 11900 (NARF-62-16T)
**SHIPPING**
of radioactive materials, evaluation of containers for, 17: 10780 (NYO-9859)
**SHIPPINGPORT PRESSURIZED WATER REACTOR**
analysis of core 1 seed 2 physics test results, 17: 11991(WAPD-PWR-TE-81)
coolant flow in, analysis of mixing behavior of, 17: 11992 (WAPD-PWR-TE-93)
core-2 power distribution, mock-up, 17: 11993 (WAPD-T-1369(Rev.))
criticality predictions for core-2, 17: 11994 (WAPD-T-1370)
data acquisition system design for, 17: 10920 (WAPD-T-1447)
environs monitoring, July to September, 1962, 17: 10867(R) (TID-17769)
fuel performance for, boron capture fraction in mockup measurements of, 17: 11995 (WAPD-T-1371(Rev.))
**SHOCK**
development from radiotherapy of carcinoma of uterine cervix, 17: 10496
**SHOCK TUBES**
plasma diagnostics in, optical interferometry, 17: 11853
properties and uses, 17: 11424
**SHOCK WAVES**
propagation in plasma, 17: 11836 (RADC-TDR-62-186)
**SILICATE ROCKS**
analysis for gold, activation, 17: 10573
**SILICON**
alloying effects on hardness of beta-quenched uranium, 17: 11097(R) (NMI-7257)
determination in plutonium by cation exchange, spectrographic, 17: 10548
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
production of p-n junctions by ion bombardment, 17: 10773 (ASD-TDR-62-428)
**SILICON CRYSTALS**
neutron tracks in, analysis of fast, 17: 11272
recombination and trapping in normal and irradiated, 17: 11383
**SILICON FLUORIDES**
stability of, radiation and thermal effects on, 17: 10516 (ORNL-TM-475)
**SILICON HYDRIDES**
stability of, radiation and thermal effects on, 17: 10516 (ORNL-TM-475)
**SILICON ISOTOPES Si-28**
alpha reactions ($\alpha$,p) at 14 Mev, proton angular distributions, 17: 11612 (AFOSR-2975)
alpha reactions ($\alpha$,n), threshold of, 17: 11715
deuteron radiative capture by, 17: 11634(R) (TID-17696)
energy levels of, spins and parities of excited, 17: 10240(R) (NP-12208)
**SILICON ISOTOPES Si-30**
electromagnetic transition probabilities from weak-coupling unified model for, 17: 11661
triton reactions (t,p) with, production of silicon-32 in, 17: 11738
vibrations in, collective, 17: 11661
**SILICON ISOTOPES Si-32**
half life, 17: 11738
production by triton reactions (t,p) with silicon-30, 17: 11738
**SILICON JUNCTIONS**
radiation damage in reactors, use as a measurement of neutron spectra, 17: 11594 (SCTM-205-62(53))
radiation effects, 17: 11263 (NP-12361)
**SILICON OXIDES**
radiation effects on surface reactivity of colloidal, 17: 10509(R) (ORNL-3320(p.30-46))
solid-phase reactions of, at high pressures, 17: 10503 (NP-12359)
sorptive properties of colloidal, for protactinium, 17: 10246(R) (ORNL-TM-403)
$SiO_2$–$UO_2$, phase diagram of, 17: 10641
**SILICON SYSTEMS**
Al–Si, corrosion properties and fabrication for cladding, 17: 11120
Al–Si–U, mechanical properties and structure, 17: 11096(R) (NMI-7256)
Fe–Si, magnetic properties, 17: 10240(R) (NP-12208)
**SILICONES**
radioinduced chlorination of polydimethyl-, and polyphenyldimethyl-, at 0°C, 17: 10715
**SILTS**
analysis of Columbia River, 17: 10850(R) (HW-73337(p.77-157))
**SILVER**
activating effects on luminescence of copper-activated zinc sulfide phosphor, 17: 11228(T)
colloidal solutions of, effects on DNA synthesis in peripheral blood cells in rabbits, 17: 10291
determination in aluminum as trace impurity, activation, 17: 10546
gamma scattering at 7 and 17 Mev, Delbruck, 17: 11745
levitation of molten, electromagnetic, 17: 11092 (NAA-SR-Memo-615)
meson ($\pi^-$) capture by, single charged particle emission in, 17: 11679
separation from aqueous solutions by solvent extraction using tri-n-butylphosphine sulfide, 17: 10754
separation from metal ionic mixtures, electrochromatographic, 17: 10753
**SILVER ALLOYS**
Cu–Au–Ag, restoration in deformed, 17: 10240(R) (NP-12208)
**SILVER CHLORIDE CRYSTALS**
radioinduced luminescence in, 17: 10712
**SILVER CHLORIDES**
radiation effects, 17: 11129
**SILVER FILMS**
thickness uniformity of commercial, 17: 11104 (TID-16252)
**SILVER ISOTOPES Ag-105**
hyperfine structure, 17: 11706
nuclear magnetic moment, 17: 11706
**SILVER ISOTOPES Ag-111**
energy of, from 23-Mev deuteron fission of uranium-238, 17: 11646 (UCRL-10193)
**SILVER SULFATES**
solubility in potassium sulfate electrolyte mixtures, 17: 10511(R) (ORNL-3320(p.56-82))
**SINTERING**
development of processes in, review of, 17: 11090 (IS-460)
**SIOUX FALLS POWER REACTOR**
heat transfer studies for, 17: 10812
testing of, summary of single-rod burnout heat flux experiments, 17: 11977 (ACNP-62028)
**SKELETON**
distribution of thorium-232, thorium-228, and radium-228 after injection of thorotrast, 17: 10351
plutonium-239 deposition in dogs, long-term study, 17: 10329
radium distribution and retention in, 17: 10309 (TID-17644)
**SKIN**
pathological effects of heavy particles from cosmic radiation on mammalian, 17: 10363(R) (TID-17676)
**SKIN DISEASES**
radiation effects on tubercular lupus, 17: 10441
radioinduced dermititis on rabbit ears, reactions of boron-10 and thermal neutron, 17: 10475
**SKIN GRAFTING**
radiation effects in rabbits, role of antibodies in, 17: 10425
**SKIN LESIONS**
radioinduced acute, therapy using pancreas extract, 17: 10490
radioinduced, pathology and treatment, 17: 10494

**SLUG CANNING**
techniques for, development of, 17: 11130
**SLUGS**
properties of powder metallurgy improved impact extrusions of aluminum as, 17: 11177
**SODIUM**
corrosive effects on metals at 1000 to 1600°F, 17: 11129
heat transfer under boiling and condensing conditions, 17: 11098(R) (NP-12433)
nuclear quadrupole resonance, 17: 10592 (IS-520)
photoionization of, cross sections for, 17: 10681(R) (TID-17743)
radiation effects on urinary excretion of, x, 17: 10463
radiation effects, 17: 11129
separation from other metals in pyridine hydrochloride by ion exchange, 17: 10747 (TID-15923)
**SODIUM ALUMINUM SILICATES**
solid-phase reactions of, at high pressures, 17: 10503 (NP-12359)
**SODIUM BORATES**
perhydrodeca-, effectiveness for neutron capture therapy of brain tumors in man, 17: 10282
**SODIUM CARBONATES**
$Li_2CO_3$–$K_2CO_3$–$Na_2CO_3$, heat transfer to uranium from molten, 17: 10805 (Y-1410)
**SODIUM CHLORIDE CRYSTALS**
vacancies produced by fast neutrons in gamma-irradiated, 17: 11377
**SODIUM CHLORIDES**
analysis for cesium, spectrometric, 17: 10565
luminescence from dissolution in water of irradiated, quenching effects of oxygen on, 17: 10612
self-diffusion effects of, on water at 25°C, 17: 10613
BaCl–NaCl, testing for use in viscous protection of high-temperature dies, 17: 11081(R) (ASD-TR-7-886(Vol. VII))
$MgCl_2$–KCl–NaCl, solvent properties for cerium and uranium from bismuth–magnesium alloy at 500°C, 17: 10581 (BNL-639)
**SODIUM CHLORITES**
oxidative effects on iodine-131 solutions, 17: 10682
**SODIUM CYANIDES**
preparation of carbon-14-labeled, 17: 10517 (PAN-336/XIII)
**SODIUM FLUORIDES**
NaF–$ThF_4$–$UF_4$, phase equilibria in, 17: 11216
**SODIUM IODIDE CRYSTALS**
pulse amplitude resolution in thallium-activated, 17: 10964
**SODIUM ISOTOPES Na-22**
determination in stone meteorites, radiometric, 17: 10839
production and separation of, method for, 17: 10676 (NP-12231)
production in aluminum-27 (p,3p3n) reactions, cross sections for, 17: 11663
separation from sodium hydroxide amalgams, 17: 10508(R) (ORNL-3320(p.22-9))
**SODIUM ISOTOPES Na-23**
energy level transitions in, 17: 11660
neutron resonance integral, 17: 11979(R) (DP-805)
nuclear quadrupole coupling constants in sodium nitrite, temperature dependence of, 17: 10646
nuclear spin flop-in transitions, 17: 11299(R) (ANL-6612)
separation from sodium hydroxide amalgams, 17: 10508(R) (ORNL-3320(p.22-9))
**SODIUM ISOTOPES Na-24**
half life, 17: 11628 (TID-15849)
production in aluminum-27 (p,3pn) reactions, cross sections for, 17: 11663
**SODIUM MOLYBDATES**
molecular condensation in reactions with nitric acid, conductometric studies of, 17: 10611(T) (UCRL-Trans-894(L))
**SODIUM NITRATES**
reactions with TBP, thermal effects on, 17: 10510(R) (ORNL-3320 (p.47-55))
salting-out properties in uranyl nitrate extraction from aqueous solutions, 17: 10770
$KNO_3$–$NaNO_3$, properties of cobalt(II) ions in, effects of bromides, chlorides, and fluorides on, 17: 10605(R) (TID-17816)
**SODIUM NITRITES**
sodium-23 nuclear quadrupole coupling in, temperature effects on, 17: 10646
**SODIUM PHOSPHATES**
solubility in benzene, 17: 10740(R) (ORNL-TM-181)
**SODIUM REACTOR EXPERIMENT**
fuel element dejacketing studies, 17: 10743(R) (ORNL-TM-457)
fuel rod bowing in operation, 17: 12017
**SODIUM SULFATES**
reactions with alkaline earth and rare earth elements, thorium, and uranium, precipitation, 17: 10621
**SODIUM SYSTEMS**
K–Na–$UO_2$, studies of slurry as potential fuel, 17: 11077 (ANL-6644)
**SOILS**
analysis for radium-226, radiochemical, 17: 10531 (ANL-6637(p.97-9))
fission product transport through, 17: 10820 (BNL-6554)
**SOLAR BATTERIES**
development of flat-plate thermoelectric, 17: 11300 (ASD-TDR-62-214)
development of radiation-resistant cell, 17: 10777(R) (NP-12474)
radiation effects, 17: 11263 (NP-12361)
**SOLAR FLARES**
cosmic ray intensity effects of, 17: 11455
effects of simulated, on space vehicle shielding, 17: 11902 (ORNL-3317)
**SOLAR RADIATION**
interactions with geomagnetic fields, investigation of, 17: 11449 (ML-975)
**SOLENOIDS**
current-carrying capacity of superconductor, 17: 11349
electric current persistence in superconducting, 17: 11404
particle dynamics in field of tapered, adiabatic approximation for, 17: 11795 (SLAC-4)
**SOLID PROPELLANTS**
performance of lithium hydride, for nuclear rockets, effects of lithium-6 and -7 on, 17: 12034 (NP-12353)
**SOLIDS**
color and stoichiometry in, correlation of, 17: 11327 (TID-15759)
phonon-phonon interactions in Bose systems, 17: 11411
thermal capacity and conductivity of, flash method of measuring, 17: 11200 (USNRDL-TR-599)
thermionic emission from, effects of band structure on, 17: 11336 (UCRL-6820)
**SOLUTIONS**
aging, oxidation, and ultraviolet radiation effects on iodine-131, 17: 10682
analysis of, technique for spectrographic, 17: 10952
effect of OH radicals and H atoms on, comparison with x-ray effects, 17: 10717
**SOLVENT EXTRACTION PROCESSES**
development for processing spent reactor fuels, 17: 10743(R) (ORNL-TM-457)
methods for separation of inorganic ions, evaluation of surface-active agents in, 17: 10749 (TID-17746)
operating control of, using an acidity meter, 17: 10972
**SOLVENT PARTITION**
of mineral acids between organic extractants and water, theory of, 17: 10767
**SOLVENTS**
association, conductance, and physical properties of organic, tables on, 17: 10504 (NYO-9696)
**SOVIET UNION**
radiation protection regulations, 17: 10870(T) (JPRS-16995)
**SPACE POWER UNIT REACTOR**
development, 17: 12036(R) (SY-5396-R3)
**SPACE VEHICLES**
development of single-stage nuclear, 17: 12038
power for, reactor shield design for producing, 17: 12039
power systems, review, 17: 12035 (NP-12492)
power utilization concepts, 17: 12033 (ASD-TDR-62-591)
propulsion systems for, closed-loop dynamics of nuclear, 17: 12037
shielding studies, 17: 11902 (ORNL-3317)
**SPALLATION**
alpha emission in, 17: 11663
thresholds for copper, low-pressure, 17: 11326 (SC-4747(RR))
**SPARK DETECTORS**

operation of parallel, efficiency of, 17: 11048
spark formation along particle track in, 17: 11038
**SPECTRA**
line widths in, calculation by Green's functions, 17: 11358
**SPECTROMETERS**
design and performance of direct-reading photoelectric, 17: 10953
design for determination of uranium isotopes, 17: 10971
design of echelle grating, for determination of isotopic abundance of uranium, 17: 10970
design of Fabry-Perot, for isotopic analyses, 17: 10969
design of multichannel, 17: 11049
resolving power and solid angle of single-lens, 17: 10895 (KFK-113)
**SPECTROPHOTOMETERS**
design of cell assembly for, 17: 10511(R) (ORNL-3320(p.56-82))
**SPECTROPHOTOMETRY**
development of deuterated high-temperature solvents for, 17: 10511(R) (ORNL-3320(p.56-82))
**SPECTROSCOPY**
apparatus for the preliminary evaporation of trace impurities from samples, 17: 10951
application of Wigner coefficients for $SU_3$ group to, 17: 11928
determination of isotopic abundances, 17: 10969
development of microwave and radiofrequency, 17: 10514(R) (ORNL-3320(p.104-25))
method suitable for both powders and solutions, 17: 10952
nuclear, application of fast-slow coincidence circuit with time to pulse-height converter to, 17: 11033
**SPERM**
radioinduced chromosome breakage in, in Drosophila, 17: 10403
**SPERMATOGENESIS**
radiation effects in mice, chronic gamma exposure, 17: 10361 (TID-15852)
radiosensitivity in female and male chick embryos, 17: 10375
**SPHERES**
packing in rhombohedron at maximum density, calculations for, 17: 11088 (HW-73057)
**SPLEEN**
protective effects of foreign cells of, on blood and tissue changes in lethally irradiated mice, 17: 10434
protective effects of extracts of, against radiation injuries in hematopoietic system in guinea pigs, 17: 10369
protective effects of extracts of, against radiation injuries in hematopoietic system in guinea pigs, 17: 10370
radiation injuries in, effects of spleen extract injections in guinea pigs on, 17: 10369
**SPUTTERING**
energy of atoms in, calorimetric measurement of average, 17: 11374
mechanism of, effects of incident ion angle, 17: 11318 (NP-12357)
**STABLE ISOTOPES**
uses in physical chemistry, 17: 10643
**STACK DISPOSAL**
monitoring for beta activity in, design of detector for, 17: 11017
**STAINLESS STEEL**
bonding of, stability of adhesives for, 17: 11175
buckling of tubes of, effects of lateral external pressure on creep and instantaneous, 17: 11192 (ORNL-3299)
corrosion by hydrofluoric acid–nitric acid, 17: 10246(R) (ORNL-TM-403)
corrosion by Purex waste, 17: 10246(R) (ORNL-TM-403)
corrosion of, by steam–water spray, 17: 11941(R) (EURAEC-475)
corrosion of pure 18/8, by hydrochloric acid, 17: 11115(T,R) (EURAEC-482)
corrosion studies of, technical progress review, 17: 11129
decontamination of type 304, 17: 11959 (TID-15779)
mechanical properties, 17: 11129
sorptive properties for promethium-147, surface, 17: 11244
structure of pure 18/8, 17: 11115(T,R) (EURAEC-482)
tensile properties, 17: 11937(R) (ARF-4132-16)
welding to Zircaloy-2, 17: 11084(R) (EURAEC-388)
**STARS**
neutrino pair emission by stellar plasma, 17: 11446
**STATISTICS**
applications in health physics program, 17: 10869 (Y-KB-7)
derivation of fluctuation compressibility theorem and its application to the pairing model of superconductors, 17: 11398
energy eigenvalues in quantum, calculation by Green's functions, 17: 11357
spectral line widths in quantum, calculation by Green's functions, 17: 11358
use in measurement of system transfer functions, 17: 11947 (HW-SA-2558)
**STEAM**
behavior as fog-flow coolant, 17: 11965 (UNC-5008-I)
**STEEL**
corrosion by vapor and water at high temperatures, 17: 11134 (EURAEC-474)
ductile-brittle transition temperature determination, research program, 17: 11187(R) (EURAEC-447)
ductility of, effects of plastic strain on, 17: 11171(T,R) (EURAEC-330)
fracture propagation in, 17: 11187(R) (EURAEC-447)
fracture surfaces of, analysis by electron microscopy, 17: 11185 (D1-82-0169)
mechanical properties of SAE 4340, effects of potassium at 1000°F, 17: 12036(R) (SY-5396-R3)
neutron attenuation by slabs of, 17: 11900 (NARF-62-16T)
properties under shock loading, 17: 11937(R) (ARF-4132-16)
radiation effects on mechanical properties, 17: 11129
testing of, use of cesium-137 in non-destructive, 17: 10817
welding of high-strength, ductility of joints in, 17: 11113(T,R) (EURAEC-430)
**STELLARATORS**
stability of, effect of finite ion gyration radius on, 17: 11788 (MATT-119)
**STOMACH**
intragastric beta irradiation, effectiveness in treatment of peptic ulcers and gastric neoplasms, 17: 10367 (TID-17727)
sorptive capacity of dogs, effects of centimeter band radio waves on, 17: 10315
**STRAIN GAGES**
design and evaluation of 3-dimensional, 17: 10783 (TID-17773)
**STRANGE PARTICLES**
production and properties of, 17: 11556
**STRESS ANALYSIS**
dislocation concepts of plastic wave propagation, 17: 11198 (UCRL-10498)
methods in, 17: 11937(R) (ARF-4132-16)
of welded materials, 17: 11172(T,R) (EURAEC-391)
**STRONTIUM**
content in blood serum and bones in rats, mechanism of parathyroid hormone effects on, 17: 10264
determination in tap-water, x-ray fluorescence spectrometric, 17: 10553
diffusion of, in glass, activation energy and coefficient of, 17: 10642
excretion in urine, tracer study, 17: 10310(R) (TID-17789)
metabolism in skeleton of man, tracer study, 17: 10293 (BNL-6108)
reactions with ammonium nitrate and oxalate and potassium and sodium sulfates, precipitation, 17: 10621
separation from IWW Purex waste, 17: 10246(R) (ORNL-TM-403)
separation from trivalent rare earths by cation exchange, 17: 10734 (IS-508)
solvent extraction from purex wastes, flowsheet for, 17: 10740(R) (ORNL-TM-181)
**STRONTIUM BORIDES**
electric properties, 17: 11306 (IS-473)
**STRONTIUM ISOTOPES**
toxic effects in dogs, 17: 10294(R) (COO-226)
**STRONTIUM ISOTOPES Sr-85**
content in blood and bone of rats, age and sex dependence of, 17: 10347
metabolism in bones of rats treated with testosterone, 17: 10348
precipitation from urine as oxalate and phosphate, 17: 10276
production and separation of, method for, 17: 10676 (NP-12231)
**STRONTIUM ISOTOPES Sr-86**
energy levels in, structure of low-lying $2^+$, 17: 11698
**STRONTIUM ISOTOPES Sr-88**
electron inelastic scattering by, partial-wave analysis of, 17: 11710
**STRONTIUM ISOTOPES Sr-89**

content in blood and bone of rats, age and sex dependence of, 17: 10347
energy of, from 23-Mev deuteron fission of uranium-238, 17: 11646 (UCRL-10193)
metabolism in bones of rats treated with testosterone, 17: 10348
separation from dodecylbenzenesulfonate solutions, 17: 10741(R) (ORNL-TM-313)
shipping of, analysis of potential hazards in, 17: 10853 (HW-SA-2518)
**STRONTIUM ISOTOPES Sr-90**
calibration of standard solutions, 17: 10299(R) (COO-226(p.66-70))
content in Atlantic surface waters, 1959–60, 17: 10835
content in milk samples from Minnesota, 1959, effects of grass contamination, 17: 10352
shipping of, analysis of potential hazards in, 17: 10853 (HW-SA-2518)
toxicity in dogs, 17: 10295(R) (COO-226(p.3-33))
uptake, review of studies of chronic, 17: 10306 (HW-SA-2577)
**STRONTIUM NITRATES**
salting-out properties in uranyl nitrate extraction from aqueous solutions, 17: 10770
**STRONTIUM SELENIDES**
$Ce_2Se_4$–$Sr_2Se_4$, thermoelectric properties, 17: 11296 (AD-278352)
**STRONTIUM SULFATES**
reduction by hydrogen, 17: 10246(R) (ORNL-TM-403)
**STRONTIUM TELLURIDES**
$Ce_2Te_4$–$Sr_2Te_4$, thermoelectric properties, 17: 11296 (AD-278352)
**STYRENE POLYMERS**
beta sorption and glass transition in, effects of temperature on, 17: 11282
luminescence and scintillation properties of 2,5-diaryl-oxazole derivatives in, 17: 11227(T)
radiation effects on, in carbon tetrachloride solutions, 17: 10709
radiation energy deposition in, reactor, 17: 11280
**STYRENES**
alpha-methyl-, effects of water on molecular weight distribution in radio-induced polymerization of, 17: 11285
**SUCCINIC ACID**
decomposition of, uranyl sensitized photo-, 17: 10697
**SUCROSE**
effects on urinary excretion of sodium and potassium after x irradiation, 17: 10463
**SUGAR BEETS**
industry, applications of radioisotopes in, 17: 10887
radiation effects on growth and sugar content, protection against, by nitrogen fertilizers, 17: 10442
**SUGARS**
crystal structure of natural, mass-spectroscopic studies of, 17: 10557
refining of, applications of radioisotopes in, 17: 10887
**SULFATES**
metabolism in liver, tracer study, 17: 10312(T) (AEC-tr-5600)
separation of iron and uranium from, by solvent extraction using bis-(2-ethylhexyl) phosphoric acid, 17: 10766
**SULFIDES**
metabolism in liver, tracer study, 17: 10312(T) (AEC-tr-5600)
**SULFONAMIDES**
5-acetamido-1,3,4-thiadiazole-2-, preparation of labeled, by activation, 17: 10683
**SULFONATES**
adsorption on hematite, isotherms for, 17: 11091(R) (MITS-49)
solvent properties for inorganic ions, 17: 10749 (TID-17746)
use of, with hexone in extraction of aluminum, cesium, and iron from purex solutions, 17: 10739(R) (ORNL-TM-27)
**SULFONES**
phenyl- and *p*-tolyl 2-octyl-2-d-, deuterium exchange and racemization of, rates of base-catalyzed, 17: 10670
protective effects against radiation injury in cells in tissue culture, 17: 10493
**SULFUR**
nuclear quadrupole resonance, 17: 10592 (IS-520)
**SULFUR FLUORIDES**
stability of, radiation and thermal effects on, 17: 10516 (ORNL-TM-475)
**SULFUR ISOTOPES**
separation by thermodiffusion concentration distribution in tubes for, 17: 11059
**SULFUR ISOTOPES S-31**
half life, 17: 11715
**SULFUR ISOTOPES S-32**
alpha reactions ($\alpha$,n), threshold of, 17: 11715
neutron reactions (n,p), use in preparation of labeled drugs, 17: 10683
neutron reactions (n,d) at 14.1 Mev, angular distributions of, 17: 11716
**SULFUR ISOTOPES S-34**
alpha reactions ($\alpha$,n), threshold of, 17: 11715
neutron reactions (n,$\gamma$), use in preparation of labeled drugs, 17: 10683
**SULFURIC ACID**
radiation chemistry of systems containing, 17: 10509(R) (ORNL-3320 (p.30-46))
**SUPERCONDUCTIVITY**
asymptotic behavior of perturbation series in, 17: 11416
electron-electron and electron-phonon interactions in, mathematical treatment of, 17: 11482 (NP-12435(Pt.II))
electron interaction in, 17: 11370
losses in, a-c, 17: 11372
radiation effect on, alpha, 17: 11291
transitions of, alloy concentration limitations for ideal, 17: 11376
**SUPERCONDUCTORS**
critical fields and currents in, 17: 11421
current-carrying capacity of solenoid, 17: 11349
elastic-wave attenuation in, mechanisms for, 17: 11400
electric current persistence in, 17: 11404
energy gap in, containing paramagnetic impurities, 17: 11405
exciton modes in, effects of impurity scattering on, 17: 11412
fluctuation compressibility theorem and its application to the pairing model of, 17: 11398
magnetic flux trapping in, temperature dependence of, 17: 11369
magnetic properties of films, 17: 11399
mean-free-path effects of impurities on, 17: 11418
properties of molybdenum-technetium, 17: 11363
reduced density matrices in coordinate space representation, 17: 11423
specific heat of transition metal, 17: 11380
thermal conductivity of second-kind, 17: 11406
**SUPERFLUIDITY**
nuclear, properties of, 17: 11735
**SURFACE WATERS**
flow velocities of, tracer techniques for measuring, 17: 10885
**SURFACES**
moisture on, design of neutron device for measurement of, 17: 10925
**SUSPENSIONS**
transport in conduits, minimum power requirements for, 17: 10809
**SWAGING**
techniques for, development of, 17: 11130
**SWINE**
effects of irradiation of testes on weight of offspring, 17: 10414
**SWITCHES**
design and performance of parallel cryotron, 17: 10927
development of circuitry for high-speed, 17: 10918 (UCRL-9035(Rev.))
**SYNCHROCYCLOTRONS**
beam frequencies and pulse control, 17: 11813
construction of symmetrical, two-way, ring, 17: 11776 (BNL-767 (p.181-97))
design of two-stage 300-Bev proton, with strong focusing, 17: 11768 (BNL-767(p.84-90))
particle losses in, due to dissociation, 17: 11799 (TID-17617)
theory of, with azimuthal variation of magnetic field, 17: 11772 (BNL-767(p.134-44))
**SYNCHROTRONS**
beam control in 7-Bev strong-focusing proton, 17: 11763 (BNL-767 (p.32-47))
beam control system for 7-Bev proton, automatic radial and phase, 17: 11764 (BNL-767(p.48-63))
design of 15-Bev proton, for use as injector, 17: 11767 (BNL-767 (p.75-83))
design of 4-6 Bev electron, 17: 11766 (BNL-767(p.67-74))
design of 50-70 Bev proton, 17: 11765 (BNL-767(p.64-6))
design of 500-Bev proton, 17: 11767 (BNL-767(p.75-83))
electron oscillation damping constants in, effect of nonlinear radiated energy expressions on, 17: 11787 (LNF-62/96)

electron radiation in, study of coherent, 17: 11770 (BNL-767(p.100-5))
magnet alignment scheme for, 17: 11786 (CTSL-36)
magnets for strong-focusing 7-Bev, parameters, magnetic measurements, and field correction methods for, 17: 11762 (BNL-767(p.1-31))
particle motion in, analog computer for studying, 17: 11773 (BNL-767(p.145-60))
particle motion in, phase-locked oscillator analog for studying, 17: 11774 (BNL-767(p.161-71))
use of, in colliding proton beam experiments, 17: 11775 (BNL-767 (p.172-6))
**SYRINGES**
radiosterilization of disposable hypodermic, commercial plant for, 17: 10266
**SYSTEMS FOR NUCLEAR AUXILIARY POWER**
shield design for, for producing power, 17: 12039
**SYSTEMS FOR NUCLEAR AUXILIARY POWER (SNAP-2)**
development, 17: 11986 (NAA-SR-6307)
**SYSTEMS FOR NUCLEAR AUXILIARY POWER (SNAP-10)**
thermoelectric element process development variables for, statistical analysis of, 17: 11314 (NAA-SR-7288)

# T

**TALCS**
radioresistance effects on insulating silicate-filled rubber vulcanizates, 17: 11286
**TANDERIL**
protective effects against radiation, 17: 10472
**TANTALUM**
corrosion studies of, technical progress review, 17: 11129
deformation at low and moderate temperatures, 17: 11223
fabrication of, by rolling and swaging, 17: 11094(R) (NMI-2113)
gamma scattering at 7 and 17 Mev, Delbruck, 17: 11745
hardness, 17: 11093(R) (NMI-2112)
hardness, 17: 11094(R) (NMI-2113)
neutron capture by, gamma emission in fast, 17: 11659
oxidation of, mechanisms in anodic, 17: 11138
sorptive properties for promethium-147, surface, 17: 11244
stress-rupture properties at 2600°C in argon and hydrogen, 17: 11087(R) (GEMP-19A)
superconductivity transitions in, ideal, 17: 11376
**TANTALUM ALLOYS**
Ir–Ta, hardness, 17: 11093(R) (NMI-2112)
Re–Ta, fabrication of, by rolling and swaging, 17: 11094(R) (NMI-2113)
Re–Ta, hardness, 17: 11094(R) (NMI-2113)
Re–Ta–W, hardness, 17: 11094(R) (NMI-2113)
Re–Ta–W, hardness, 17: 11093(R) (NMI-2112)
Ru–Ta, extrusion, 17: 11093(R) (NMI-2112)
Ru–Ta, fabrication of, by rolling and swaging, 17: 11094(R) (NMI-2113)
Ru–Ta, hardness, 17: 11093(R) (NMI-2112)
Ta–Tc, phase studies on, 17: 11220
Ta–W, hardness, 17: 11094(R) (NMI-2113)
**TANTALUM BORIDES**
bibliography on preparation and properties of, 17: 10579 (ASD-TDR-62-873)
**TANTALUM BROMIDES**
reactions with pyridine, 17: 10500 (IS-385)
**TANTALUM CARBIDES**
melting point, 17: 11201(T) (AEC-tr-5598)
superconductivity of, negative results, 17: 11391
HfC–TaC, melting point, 17: 11201(T) (AEC-tr-5598)
NbC–TaC, melting point, 17: 11201(T) (AEC-tr-5598)
NbC–TaC–ZrC, melting point, 17: 11201(T) (AEC-tr-5598)
TaC–$W_2C$, melting point, 17: 11201(T) (AEC-tr-5598)
TaC–ZrC, melting point, 17: 11201(T) (AEC-tr-5598)
**TANTALUM CHLORIDES**
reactions with pyridine, 17: 10500 (IS-385)
**TANTALUM IODIDES**
reactions with pyridine, 17: 10500 (IS-385)
**TANTALUM ISOTOPES Ta-181**
deuteron reactions (α,p), angular momentum in, 17: 11662
neutron scattering at 0.3 to 1.5 Mev, cross sections for inelastic, 17: 11936(R) (ANL-6672)
**TANTALUM NITRIDES**
spectral emissivity at 1648 to 2070°K, 17: 11191(R) (NP-12483)
vaporization at 1341, 1420, and 1498°K, mechanism of, 17: 11191(R) (NP-12483)
**TARTARIC ACID**
decomposition of, uranyl sensitized photo-, 17: 10697
**TBP PROCESS**
fixation of TBP-25 waste in glass, 17: 10246(R) (ORNL-TM-403)
**TECHNETIUM**
nuclear quadrupole resonance, 17: 10592 (IS-520)
**TECHNETIUM ALLOYS**
Cr–Tc, phase studies on, 17: 11220
Fe–Tc, phase studies on, 17: 11220
Hf–Tc, phase studies on, 17: 11220
Mn–Tc, phase studies on, 17: 11220
Mo–Tc, crystalline-phase and superconducting properties of, 17: 11363
Mo–Tc, phase studies on, 17: 11220
Nb–Tc, phase studies on, 17: 11220
Sc–Tc, phase studies on, 17: 11220
Ta–Tc, phase studies on, 17: 11220
Tc–Ti, phase studies on, 17: 11220
Tc–V, phase studies on, 17: 11220
Tc–W, phase studies on, 17: 11220
Tc–Zr, phase studies on, 17: 11220
**TELLURIUM**
radiolysis of alkaline solutions of, mechanism in gamma, 17: 10693
**TELLURIUM ISOTOPES Te-122**
energy levels in, structure of low-lying $2^+$, 17: 11698
**TELLURIUM ISOTOPES Te-135**
yields from uranium-235 thermal fission, 17: 11746
**TEMPERATURE**
distribution in slab with internal heat generation, computer program for one-dimensional, 17: 10797 (KAPL-M-EC-27)
**TERBIUM**
determination in aluminum as trace impurity, activation, 17: 10546
fluorescent lifetime of, in the presence of other rare-earth ions, 17: 10626
**TERBIUM ALLOYS**
Lu–Tb, electric conductivity, 17: 11190 (IS-477)
**TERBIUM HYDRIDES**
electronic structure, 17: 11329 (TID-15934)
magnetic properties, 17: 11329 (TID-15934)
**TERBIUM ISOTOPES Tb-153**
neutron emission from compound nuclei of, angular momentum effects on, 17: 11645 (UCRL-10099)
**TERBIUM ISOTOPES Tb-157**
neutron emission from compound nuclei of, angular momentum effects on, 17: 11645 (UCRL-10099)
**TEREPHTHALIC ACID, ETHYLENE POLYMER ESTERS**
beta sorption and glass transition in, effects of temperature on, 17: 11282
thickness uniformity of commercial Mylar foils, 17: 11104 (TID-16252)
**TERPHENYLS**
stability of, radiolytic and thermal, 17: 10689
**TESTOSTERONE**
effects on bone metabolism of strontium-85 and strontium-89 in rats, 17: 10348
**TEXTILES**
thread measurements in, design of beta thickness gage for, 17: 10979
**THALLIUM**
determination in urine, spectrophotometric, 17: 10550
separation from metal ionic mixtures, electrochromatographic, 17: 10753
**THALLIUM BROMIDES**
luminescence spectra of aqueous solutions of, 17: 10650
**THALLIUM CHLORIDES**
luminescence spectra of aqueous solutions of, 17: 10650
thallium isotope mobility in molten, temperature dependence of, 17: 10647
**THALLIUM ISOTOPES**
mobility in molten thallium chloride, temperature dependence of, 17: 10647

**THALLIUM ISOTOPES Tl-203**
electron (L) internal conversion in, 17: 11618 (BNL-6647)
**THALLIUM SULFATES**
luminescence spectra of aqueous solutions of, 17: 10650
**THERMAL CAPACITY**
measurement of, in solids at −180 to +200°C, flash method for, 17: 11200 (USNRDL-TR-599)
**THERMAL CONDUCTIVITY**
measurement of, in solids at −180 to +200°C, flash method for, 17: 11200 (USNRDL-TR-599)
**THERMAL DIFFUSION**
efficiency in separation of xenon isotopes, 17: 11051 (BNL-15343)
**THERMAL NEUTRONS**
biological effectiveness of, for brain tumor therapy and rabbits' ears, 17: 10475
biological effects on diploid and hexaploid species of *Avena*, 17: 10457
diffusion in moderators, parameters for, 17: 11605
effects on cytology and morphology of tomatoes, 17: 10452
effects on embryo-endo sperm ratios in seeds, 17: 10386
effects on growth and survival of durum wheat, comparison with effects of mutagenic agents, 17: 10388
mutagenic effects on "Cappelli" durum wheat, 17: 10390
reactions with uranium-235 at 6.68 ev, resonance, 17: 11655
scattering and slowing-down by hydrogenous compounds, 17: 11602
scattering by water, 17: 11589 (HW-75526)
spectra of, in split reactor cores, 17: 12030
transport in pulsed water systems, measurement of extrapolation lengths for, 17: 11600 (WAPD-T-1490)
**THERMAL RADIATION**
production in reactors, 17: 11619 (CEA-2172)
transmission of, from nuclear detonations in real atmospheres, 17: 11298 (AFCRL-62-456)
**THERMAL STRESSES**
analysis of problems in thermoviscoelasticity, 17: 11338 (UCRL-13059)
in welding processes, study of residual effects of, 17: 11173(T,R) (EURAEC-446)
**THERMIONIC CELLS**
bibliography, 17: 11322 (NP-12429)
development of encapsulated, 17: 11313(R) (MND-2945-1)
development of low-temperature, 17: 11295(R) (AD-277713)
electric properties of rarefied plasma filled, 17: 11437
oscillations in cesium and mercury diodes, 17: 11441
performance of cesium, in parallel-series circuits, 17: 11315 (NAA-SR-7661)
plasma oscillations in potassium cell, 17: 11837 (TID-16215)
theory of, 17: 11336 (UCRL-6820)
**THERMOCOUPLES**
design for in-core power monitoring to 1800°F, 17: 10940
development of plasma, 17: 11311(R) (LAMS-2796)
development of tungsten–rhenium, for temperature measurements in Zircaloy-2 weldments, 17: 11105 (TID-17734)
radiation effects on, thermal neutron, 17: 11273
**THERMODYNAMICS**
cosmic-radiation generation in nebulae in, 17: 11456
energy eigenvalues in quantum, calculation by Green's functions, 17: 11357
generalization of Planck's radiation law in $A$-$\sigma$-$I$ theory, 17: 11429
Gibbs statistics for ideal and real gaseous systems of isotopes, 17: 10655
spectral line widths in quantum, calculation by Green's functions, 17: 11358
**THERMOELECTRIC CELLS**
bibliography, 17: 11322 (NP-12429)
development, 17: 11935(R) (ANL-6658)
development of flat-plate solar, 17: 11300 (ASD-TDR-62-214)
measurement of Seebeck coefficient of, 17: 11316 (NAA-SR-Memo-6741)
**THERMOELECTRIC MATERIALS**
preparation and properties, 17: 11293(R) (AD-277122)
**THERMOELECTRIC PROPERTIES**
effect of band structure on, 17: 11336 (UCRL-6820)
research progress on, 17: 11294(R) (AD-277223)
**THERMONUCLEAR EXPLOSIONS**
effects of high-altitude, on resonance of earth-ionosphere cavity, 17: 10828
wave propagation in atmosphere from, 17: 10837
**THERMONUCLEAR REACTIONS**
book: *Plasma Physics and Controlled Thermonuclear Reactions*, 17: 11894
**THERMONUCLEAR REACTORS**
cyclotron radiation losses in, 17: 11849
development, 17: 11831(R) (LAMS-2816)
**THICKNESS GAGES**
accuracy and sensitivity of radioisotopic, 17: 10978
amplifier design, for industrial use as, sensitive electrometer, 17: 11016
design of beta-ray, for pulp and paper research, 17: 10980
design to measure textile threads, 17: 10979
use of alpha, in measuring thickness uniformity of commercial foils, 17: 11104 (TID-16252)
use of beta-ray, for moisture determination, 17: 10981
**THIOCYANATES**
use of tricaprylmethylammonium, for cobalt extraction, 17: 10540 (TID-17745)
**THIOLS**
effects on photoreduction of benzophenone, 17: 10680(R) (TID-17584)
**THORIUM**
analysis of, by delayed neutron emission from fission in, 17: 10534 (IA-784)
determination in aluminum as trace impurity, activation, 17: 10546
determination in monazite sand using pyrophosphoric acid decomposition, 17: 10556
determination in thoriated tungsten using thoron, colorimetric, 17: 10561
proton reactions in, actinium isotopes from, 17: 11663
reactions with ammonium nitrate and oxalate, precipitation, 17: 10621
separation from aqueous solutions by solvent extraction using thenoyltrifluoroacetone, 17: 10727 (BNL-6099)
separation from aqueous solutions and uranium by solvent extraction using butyl phenyl phosphates and butyl phosphates, 17: 10738 (ORNL-3374)
separation from aqueous solutions by solvent extraction with cerium using TBP, 17: 10760
solvent extraction using thenoyltrifluoroacetone, synergistic effects of tributyl phosphate and trioctylphosphine oxide, 17: 10729 (BNL-6188)
**THORIUM ALLOYS**
phase studies, 17: 11126
Pu–Th–U, phase studies, 17: 11935(R) (ANL-6658)
**THORIUM BORIDES**
bibliography on preparation and properties of, 17: 10579 (ASD-TDR-62-873)
**THORIUM CHLORIDES**
reactions with aluminum chlorides, complex formation in, 17: 10586 (HW-SA-2597)
**THORIUM(IV) FLUORIDES**
$NaF–ThF_4–UF_4$ phase equilibria in, 17: 11216
**THORIUM ISOTOPES**
toxic effects in dogs, 17: 10294(R) (COO-226)
**THORIUM ISOTOPES Th-227**
formation cross section for neon-22 reaction with thorium-232, 17: 11473 (JINR-P-1071)
**THORIUM ISOTOPES Th-228**
content in skeleton, correlation with injection of thorotrast, 17: 10351
dosage determinations in tissue, 17: 10301(R) (COO-226(p.78-85))
pathological effects of injected, in dogs, 17: 10296(R) (COO-226(p.35-49))
separation from uranium-233, 17: 10246(R) (ORNL-TM-403)
toxicity in dogs, 17: 10295(R) (COO-226(p.3-33))
**THORIUM ISOTOPES Th-232**
content in skeleton, correlation with injection of thorotrast, 17: 10351
neon ion reactions (neon-22), 17: 11473 (JINR-P-1071)
**THORIUM ISOTOPES Th-234**
distribution in tissues and removal by chelation, effects of physical state, 17: 10523 (ANL-6637(p.5-8))
removal of internally deposited, evaluation of chelating agents, 17: 10333
**THORIUM NITRATES**

denitration by steam, 17: 10743(R) (ORNL-TM-457)
separation from nitric acid by anion exchange, prediction of loss curves in, 17: 10763
**THORIUM OXIDE POWDERS**
fabrication by ultrasonic compaction, 17: 11162 (CEND-153(Vol.II) (p.163-94))
**THORIUM OXIDES**
$ThO_2$–$UO_2$, criticality and exponential studies of water-moderated lattices of, 17: 11938 (BAW-1257)
$ThO_2$–$UO_2$, fabrication, 17: 11109(T,R) (EURAEC-338)
$ThO_2$–$UO_2$, fabrication, 17: 11111(T,R) (EURAEC-407)
$ThO_2$–$UO_2$, fabrication, 17: 11967(T,R) (EURAEC-499)
$ThO_2$–$UO_2$, reactivity studies of, 17: 11109(T,R) (EURAEC-338)
$ThO_2$–$UO_2$, reactivity calculations for, 17: 11111(T,R) (EURAEC-407)
$ThO_2$–$UO_2$, reactivity effects of long-term irradiation of, 17: 11967(T,R) (EURAEC-499)
**THORIUM(IV) OXIDES**
distribution in tissues, 17: 10351
fabrication by vibratory compaction, 17: 11146 (CEND-153(Vol.I)(p.61-74))
preparation for vibratory compaction by sol-gel process, 17: 11144 (CEND-153(Vol.I)(p.23-38))
surface energies of, theoretical estimation of, 17: 11217
$ThO_2$–$UO_2$, extrusion, 17: 11161 (CEND-153(Vol.II)(p.135-54))
$ThO_2$–$UO_2$, fabrication by vibratory compaction, 17: 11146 (CEND-153 (Vol.I)(p.61-74))
$ThO_2$–$UO_2$, preparation for vibratory compaction by sol-gel process, 17: 11144 (CEND-153(Vol.I)(p.23-38))
$ThO_2$–$UO_2$, radiation effects, 17: 11154 (CEND-153(Vol.II)(p.3-38))
$ThO_2$–$UO_2$, radiation effects, 17: 11155 (CEND-153(Vol.II)(p.39-65))
**THORIUM SILICATES**
solid-phase reactions of, at high pressures, 17: 10503 (NP-12359)
**THORIUM SULFIDES**
preparation and properties of, 17: 11935(R) (ANL-6658)
**THULIUM**
determination in aluminum as trace impurity, activation, 17: 10546
solvent extraction using thenoyltrifluoroacetone, synergistic effects of tributyl phosphate and trioctylphosphine oxide, 17: 10729 (BNL-6188)
**THYMIDINE**
metabolism in bone marrow, tracer study, 17: 10292 (BNL-6106)
uptake of tritium-labeled, by peripheral blood cells in rabbits, 17: 10291
**THYMUS**
role of, in recovery of immunological reactivity in x-irradiated mice, 17: 10412
**THYROID GLAND**
analysis for micro amounts of iodine-131, external counting, 17: 10849(R) (HW-73337(p.29-76))
function after therapy with iodine-131, tracer method using iodine-132, 17: 10342
function of, effects of atomic explosion on children exposed *in utero* in Nagasaki on, 17: 10371
iodine-131 uptake measurements, calibration system, 17: 10343
radiation effects on cancer of, in children, 17: 10262
**THYROXINE**
protective effects against post radiotherapy symptoms in man, 17: 10268
**TIME MEASUREMENT**
interaction between natural clocks and distant matter, experimental limit on, velocity-dependent, 17: 11325 (PUC-1962-68)
**TIN**
cryotron design and performance using parallel strips of, 17: 10927
determination in aluminum as trace impurity, activation, 17: 10546
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
electric resistivity of, effects of lattice vacancies on, 17: 11231
magnetic flux trapping in, temperature dependence of, 17: 11369
separation from metal ionic mixtures, electrochromatographic, 17: 10753
**TIN ALLOYS**
ultrasonic Lamb wave propagation in Zircaloy, 17: 11304 (HW-75499)
Nb–Sn, use in magnetic shielding for energetic protons, 17: 11899 (N62-10900(Pt.IV))
Sn–Ti, creep at 300 to 700°C, 17: 11211
Sn–Ti–Zr, creep properties at 300 to 700°C, 17: 11211
**TIN ISOTOPES Sn-120**
proton reactions (p,α) to 22 Mev, yields of, 17: 11696
proton reactions (p,α) at 12 to 18 Mev, isomer yields of, 17: 11697
**TISSUE CULTURES**
chemical prophylaxis of radiation injuries in cells, 17: 10491
chemotherapy and radiation effects on, of cervical and ovarian cancer cells, 17: 10261
protective effects of blood serum on irradiated cells, 17: 10429
radiation effects on development of embryonic lung cells in, 17: 10420
radioautography of tritium-labeled HeLa cells, method for electron microscopic, 17: 10284
**TISSUES**
alpha dose rate in, 17: 10301(R) (COO-226(p.78-85))
analysis for tritium as vitamin A by liquid scintillation, 17: 10552
plutonium-239 distribution in mouse, autoradiography of injected, 17: 10260
radiation effects on, effects of foreign spleen cells in mice on, 17: 10434
radiation effects on metabolic processes in, by ion displacement, enzyme studies of, 17: 10469
**TITANIUM**
bonding of, stability of adhesives for, 17: 11175
determination in aluminum, x-ray spectroscopic, 17: 10571
dissolution rate in liquid aluminum, 17: 10577 (ANL-FGF-292)
sorptive properties for promethium-147, surface, 17: 11244
spectra of, atomic absorption, 17: 10549
transformations in, martensite, 17: 11239
**TITANIUM ALLOYS**
Al–Ti–V, mechanical properties, 17: 11099(R) (NP-12475)
Al–Ti–V, phase transformations kinetics in, 17: 11248
Cr–Nb–Ti, phase studies at 600, 800, and 1000°C, 17: 11212
Cu–Ti, martensite transformations in, 17: 11239
Mo–Ti, fabrication for grain growth control, 17: 11295(R) (AD-277713)
Mo–Ti, mechanical properties of, effects of potassium vapor at 2000°F on, 17: 12036(R) (SY-5396-R3)
Nb–Ti, properties of welded, 17: 11242
Sn–Ti, creep at 300 to 700°C, 17: 11211
Sn–Ti–Zr, creep properties at 300 to 700°C, 17: 11211
Tc–Ti, phase studies on, 17: 11220
**TITANIUM BORIDES**
bibliography on preparation and properties of, 17: 10579 (ASD-TDR-62-873)
fabrication by pressing and sintering powders, 17: 11170(T) (AEC-tr-5604)
**TITANIUM CARBIDES**
physical properties, 17: 11215
**TITANIUM HYDRIDES**
NbH–TiH, crystal structure and hydrogen sorption in, 17: 11237
**TITANIUM ISOTOPES Ti-46**
energy levels of, spin and parity of 2.004-Mev, 17: 11627 (TID-15088)
**TITANIUM ISOTOPES Ti-47**
deuteron reactions in, excitation functions and cross sections for, 17: 11624 (NYO-10386)
neutron reactions (n,p) at 14.5 Mev, cross sections for, 17: 11614 (BNL-6044)
**TITANIUM ISOTOPES Ti-48**
neutron reactions (n,p) at 14.5 Mev, cross sections for, 17: 11614 (BNL-6044)
**TITANIUM ISOTOPES Ti-50**
neutron reactions (n,α) at 14.5 Mev, cross sections for, 17: 11614 (BNL-6044)
**TITANIUM OXIDES**
additive effects on reduction of uranium trioxides by ammonia, 17: 10726
**TOBACCO**
radioinduced polygenic mutability in *Nicotiana tabacum*, 17: 10387
**TRACER TECHNIQUES (BIOLOGY)**
labeling of mosquito larvae and adults with phosphorus-32, 17: 10423
technological processes in, 17: 10882
**TRACER TECHNIQUES (CHEMISTRY)**
use of, in determining plutonium extraction efficiency, 17: 10739(R) (ORNL-TM-27)
**TRACER TECHNIQUES (GEOLOGY)**

age estimation using, 17: 10832
**TRACER TECHNIQUES (MEDICINE)**
diagnosis of renal disease associated with cardiac failure by excretion of mercury-203 labeled mercaptomerin sodium, 17: 10345
localization of bone metastases by external scanning after administration of calcium-47 or strontium-85, 17: 10344
localization of bone tumor metastases by external scanning after administration of strontium-85, 17: 10279
localization of brain tumors by external scanning after administration of arsenic-74, 17: 10278
using iodine-132 to study thyroid function after therapy with iodine-131, 17: 10342
**TRADESCANTIA**
radioinduced chromosomal aberration gradients in anthers of, 17: 10454
**TRANSDUCERS**
characteristics of linear variable differential transformer gage heads, standardization of, 17: 10904 (SCTM-100-62-81)
**TRANSISTORS**
testing of, analyzer design for, 17: 10968
use in circuits for nuclear instrumentation, 17: 10957
use in electronic galvanometer, 17: 10958
use in health physics monitoring instruments, 17: 10960
use in reactor instrumentation, 17: 10989
**TRANSITION METALS**
phase studies of binary and ternary alloys of, 17: 11180 (ANL-FGF-337)
specific heats of superconducting, 17: 11380
superconductivity, 17: 11370
**TRANSPLUTONIC ELEMENTS**
adsorption of lanthanides by inorganic ion exchange materials, 17: 10740(R) (ORNL-TM-181)
**TRANSURANIC ELEMENTS**
separation by ion exchange, 17: 10771
**TRAPS**
design of, for iodine-131, 17: 10844 (CEA-Bib-29)
**TRITIUM**
age measurements with, 17: 10243 (NP-12381)
biological effects of injected in mice, 17: 10354 (BNL-6105)
content in rain water in Cologne in 1960–61, 17: 10840
determination in blood, feces, and tissues as vitamin A by liquid scintillation, 17: 10552
determination in water, 17: 10850(R) (HW-73337(p.77-157))
determination of, in gas-liquid chromatographic effluents by scintillation, flow-through method for, 17: 11027
separation from hydrogen, 17: 10240(R) (NP-12208)
**TRITONS**
energy levels of, three-body effects on wave-function calculations of, 17: 11583
interactions with deuterons at 5 to 12 Mev, neutron spectra from, 17: 11526
production in meson ($\pi^-$) capture in emulsion, 17: 11679
reactions (t,p) with silicon-30, production of silicon-32 in, 17: 11738
**TRX REACTOR**
neutron resonance integrals in, 17: 11668
**TUBERCULOSIS**
radiation effects on lupus, 17: 10441
**TUBES**
buckling of, method for predicting creep and instantaneous, 17: 11192 (ORNL-3299)
burnout of water-cooled high-pressure, equations for, 17: 10806(T) (AEC-tr-5602)
extrusion of niobium alloy, optimization studies, 17: 11140(R) (AMC-TR-7-775(VII))
fabrication of Zircaloy, 17: 11979(R) (DP-805)
gas-liquid countercurrent flow in vertical, effects of liquid viscosity on flooding in, 17: 10788 (62GL132)
heat transfer from steam-heated copper, to isopropanol, effects of surface voltage on, 17: 10801(R) (NYO-10345)
ultrasonic Lamb wave testing of Zircaloy, 17: 11304 (HW-75499)
**TUMORS**
radiation effects on islet-cell, in pancreas in rats, 17: 10432
radiation effects on reproductive capacity of leukemic cells of mammalian, ionization density, 17: 10396
radioinduced by injected plutonium-239, in dogs, 17: 10303(R) (COO-226(p.95-127))
radioinduced in lungs of mice, 17: 10476
radioinduced in mice, 17: 10360 (TID-15850)
radioinduced thymic lymphomas in mice, 17: 10354 (BNL-6105)
radiotherapy of gastric, effectiveness of beta source, 17: 10367 (TID-17727)
radiotherapy of malignant, effects of adrenal steroid therapy on symptoms from, 17: 10268
**TUNGSTEN**
analysis for thorium using thoron, colorimetric, 17: 10561
corrosion studies of, technical progress review, 17: 11129
deformation at low and moderate temperatures, 17: 11223
diffusion of beryllium in, at 1000 to 1200°C, 17: 11214
diffusion of lithium-7 through, coefficient for, 17: 11206
enthalpy at 350 to 2000°C, 17: 11207
extrusion, 17: 11094(R) (NMI-2113)
fabrication techniques for, control of grain growth by, 17: 11295(R) (AD-277713)
hardness, 17: 11093(R) (NMI-2112)
inspection of billets by gamma scanning, 17: 10816 (USNRDL-TR-602)
neutron capture by, gamma emission in fast, 17: 11659
penetration range of krypton-85 in, 17: 11612 (AFOSR-2975)
radiation effects, 17: 11129
reactions with cold gas molecules at 1710 to 2500°K, energy exchange in, 17: 10609 (UCRL-10504)
**TUNGSTEN ALLOYS**
Be–W, phase studies and structure, 17: 11214
Fe–W, thermal expansion of solid solutions, anomalies in, 17: 11238
Nb–W, properties of welded, 17: 11242
Re–Ta–W, hardness, 17: 11094(R) (NMI-2113)
Re–Ta–W, hardness, 17: 11093(R) (NMI-2112)
Ru–W, extrusion, 17: 11093(R) (NMI-2112)
Ru–W, hardness, 17: 11093(R) (NMI-2112)
Ta–W, hardness, 17: 11094(R) (NMI-2113)
Tc–W, phase studies on, 17: 11220
**TUNGSTEN CARBIDES**
hot pressing of powders, 17: 11170(T) (AEC-tr-5604)
melting point, 17: 11201(T) (AEC-tr-5598)
NbC–$W_2C$, melting point, 17: 11201(T) (AEC-tr-5598)
TaC–$W_2C$, melting point, 17: 11201(T) (AEC-tr-5598)
$W_2C$–ZrC, melting point, 17: 11201(T) (AEC-tr-5598)
**TUNGSTEN COUPLES**
Re–W, development for temperature measurements in Zircaloy-2 weldments, 17: 11105 (TID-17734)
**TUNGSTEN ELECTRODES**
preparation and properties of, for use in ion propulsion systems, 17: 11080 (ASD-TDR-62-756)
**TUNGSTEN ISOTOPES**
separation by gaseous diffusion, feasibility, 17: 11052 (TID-15348)
**TUNGSTEN ISOTOPES W-182**
energy levels of, perturbation corrections to, 17: 11665
**TUNGSTEN ISOTOPES W-184**
energy levels, 17: 11717
neutron capture cross sections and resonances for, 17: 11805(R) (TID-17728)
neutron scattering at 0.3 to 1.5 Mev, cross sections for inelastic, 17: 11936(R) (ANL-6672)
**TUNGSTEN ISOTOPES W-186**
deuterons radiative capture in, 17: 11634(R) (TID-17696)
neutron resonance integral, 17: 11979(R) (DP-805)
**TUNGSTEN SYSTEMS**
C–Nb–W–Zr, extrusion of tubing from, optimization studies, 17: 11140(R) (AMC-TR-7-775(VII))
**TURBINES**
bearings for, development of gas-lubricated, 17: 10781(R) (TID-17311)

## U

**ULTRASONICS**
attenuation in liquid helium, 17: 11415
attenuation in superconductors, mechanisms for, 17: 11400

Lamb wave propagation in Zircaloy, 17: 11304 (HW-75499)
use for cleaning OMRE fuel elements, 17: 11954(R) (NYO-10284)
**ULTRAVIOLET RADIATION**
effects on catalase accumulation in conidia of *Aspergillus niger*, 17: 10397
effects on cellular and nuclear growth in *Paramecium aurelia*, 17: 10408
effects on phosphatases, protective effect of cysteine against, 17: 10405
effects on restoration of RNA in amoeba, 17: 10410
mechanism of Borek-Ryan effect, 17: 10382
mutagenic effects on Drosophila, 17: 10393
**UNDERGROUND EXPLOSIONS**
aftershock in CIMARRON event, long-range measurements of, 17: 10242 (NP-12339)
nuclear, seismic signals from GNOME, compilation of recordings of, 17: 10824 (NP-12462)
seismic data for STILLWATER, 17: 10244 (NP-12444)
seismic measurements from MAD event, 17: 10245 (NP-12524)
seismic reactions of nuclear, data obtained by long-range sites on, 17: 11321 (NP-12418)
seismic waves from ARMADILLO, analysis of measurements of, 17: 10823 (NP-12445)
**URANIUM**
analysis of, by delayed neutron emission from fission in, 17: 10534 (IA-784)
analysis using direct-reading emission spectroscopy, isotopic, 17: 10971
annealing of, heat-transfer conditions in salt-bath system for, 17: 10805 (Y-1410)
determination by potentiometric titration, 17: 10737 (NBL-189)
determination in aluminum as trace impurity, activation, 17: 10546
determination in crystals, fission, 17: 10555
determination in oxides, 17: 11108(T,R) (EURAEC-307)
determination in water, 17: 10850(R) (HW-73337(p.77-157))
diffusion of chromium and iron in beta, 17: 11079 (ANL-FGF-334)
distribution between bismuth–magnesium alloy and magnesium chloride–potassium chloride–sodium chloride eutectic at 500°C, 17: 10581 (BNL-639)
electron energy levels in, indirect relativistic effects on 5f, 17: 11395
equation of state in critical region, 17: 11183 (AWRE-0-61/62)
etching by cathodic arc, 17: 11089 (HW-SA-2559)
excretion in urine, mathematical analysis of data on lung-stored, 17: 10311 (Y-KB-1)
excretion of inhaled, in urine, 17: 10305 (HASL-120)
gamma scattering at 7 and 17 Mev, Delbruck, 17: 11745
handling of enriched, design of shipping container for, 17: 10862 (RFP-290)
hardness, alloying effects of aluminum, iron, chromium, and silicon, 17: 11979(R) (DP-805)
hardness of beta-quenched, alloying effects of aluminum, chromium, iron, and silicon, 17: 11097(R) (NMI-7257)
hydrolysis of pentavalent, 17: 10511(R) (ORNL-3320(p.56-82))
injuries in rats, effects on fine structure of kidneys tubules, 17: 10265
isotopic abundance in, measurement using an echelle grating spectrograph, 17: 10970
isotopic composition of irradiated, effects on refabrication and reprocessing, 17: 11253 (BLG-140)
levitation of molten, electromagnetic, 17: 11092 (NAA-SR-Memo-615)
mining of, 17: 10724
neutron resonance integrals in, 17: 11668
neutron resonance integrals in, 17: 11667
neutron transport in natural, 17: 11598 (TID-16304)
polarographic behavior in carbonate media, 17: 10541(T,R) (EURAEC-400)
pouring and shotting of molten, 17: 11094(R) (NMI-2113)
properties as reactor fuel, investigation of, 17: 11121
properties of, technical progress review, 17: 11126
proton reactions at 2.9 Bev, nuclear charge distributions in, 17: 11727
radioinduced swelling, 17: 11265 (TID-15774)
reactions with ammonium nitrate, precipitation, 17: 10521
reactions with yttrium at high temperatures, 17: 10239(R) (MLM-1140)
separation by amine sulfate extraction, mechanism of, 17: 10739(R) (ORNL-TM-27)
separation from aqueous solutions and thorium by solvent extraction using butyl phenylphosphates and butyl phosphates, 17: 10738 (ORNL-3374)
separation from carbonate solutions by anion exchange, 17: 10769
separation from irradiated U–Zr fuel alloy, 17: 10742 (ORNL-TM-447)
separation from irradiated fuels by solvent extraction using dibutyl ether, 17: 10755
separation from metal ionic mixtures, electrochromatographic, 17: 10753
separation from plutonium by ion exchange, 17: 11108(T,R) (EURAEC-307)
separation from sulfate solutions by solvent extraction using bis-(2-ethylhexyl) phosphoric acid, 17: 10766
separation from trivalent iron by ion exchange chromatography, 17: 10752(T) (GAT-Z-5035)
separation from unirradiated fuel elements by fluoride volatility, 17: 10728 (BNL-6148)
solvent extraction using thenoyltrifluoroacetone, synergistic effects of tributyl phosphate and trioctylphosphine oxide, 17: 10729 (BNL-6188)
solvent extraction by phosphates and phosphonates, 17: 10745 (TID-15773)
transfer from plasma to milk in sheep, tracer study, 17: 10326
use of, in nuclear power, economics and potential of, 17: 11968
x-ray-diffraction analysis of irradiated, design of unit for, 17: 10894 (HW-SA-2616)
**URANIUM ALLOYS**
preparation, 17: 11093(R) (NMI-2112)
properties of, technical progress review, 17: 11126
Al–Fe–U, mechanical properties and structure of, 17: 11096(R) (NMI-7256)
Al–Fe–U, mechanical properties and radiation effects, 17: 11095(R) (NMI-7254)
Al–U, fabrication of tubular irradiation test specimens of, 17: 11096(R) (NMI-7256)
Mo–U, fabrication and testing, 17: 11096(R) (NMI-7256)
Pu–Th–U, phase studies, 17: 11935(R) (ANL-6658)
U–Zr, dissolution, 17: 10246(R) (ORNL-TM-403)
U–Zr, processing of irradiated, 17: 10742 (ORNL-TM-447)
U–Zr, separation from unirradiated fuel elements by fluoride volatility, 17: 10728 (BNL-6148)
**URANIUM CARBIDES**
corrosion of cast, by laboratory air, 17: 11106(R) (UNC-5040)
fabrication, 17: 11114(T,R) (EURAEC-477)
fabrication, 17: 11118(T,R) (EURAEC-496)
fabrication and irradiation testing, 17: 11110(T,R) (EURAEC-387)
hydrolysis rate, 17: 11118(T,R) (EURAEC-496)
irradiation, research program on, 17: 11106(R) (UNC-5040)
oxidation, 17: 10519(T,R) (EURAEC-460)
preparation and properties of, 17: 11935(R) (ANL-6658)
processing, 17: 10743(R) (ORNL-TM-457)
processing of irradiated, 17: 10736 (NAA-SR-7511)
production of graphite-coated particle of, by fluidized bed process, 17: 11174
properties of, technical progress review, 17: 11126
radiation effects on, 17: 11114(T,R) (EURAEC-477)
radiation effects, 17: 11117(T,R) (EURAEC-491)
radiation effects on, 17: 11118(T,R) (EURAEC-496)
radiation effects at 1500°C to 10% burnup, 17: 11261 (LAMS-2814)
radiation effects on graphite-coated, microradiographic studies, 17: 11955(R) (ORNL-3372)
reactions with nitric acid, 17: 10246(R) (ORNL-TM-403)
reactions with water, 17: 10246(R) (ORNL-TM-403)
separation from plutonium, 17: 10737 (NBL-189)
separation from unirradiated fuel elements by fluoride volatility, 17: 10728 (BNL-6148)
thermal expansion, research program on, 17: 11106(R) (UNC-5040)
thermal expansion, 17: 11108(T,R) (EURAEC-307)
PuC–UC, phase studies, 17: 11181 (ANL-FGF-345)
UC–ZrC, fabrication, 17: 11311(R) (LAMS-2796)
UC–ZrC, thermoelectric properties at 1700 to 2620°K, 17: 11436
U–UC, fabrication and sintering, 17: 11118(T,R) (EURAEC-496)
**URANIUM CHLORIDES**
reactions with aluminum chlorides, complex formation in, 17: 10586

(HW-SA-2597)
**URANIUM(VI) CHLORIDES**
separation from fused salt media by solvent extraction, 17: 10765
**URANIUM COMPLEXES**
with chloride, anion exchange and nonaqueous studies, 17: 10585 (HW-SA-2596)
**URANIUM(IV) FLUORIDES**
$NaF-ThF_4-UF_4$, phase equilibria in, 17: 11216
**URANIUM(VI) FLUORIDES**
critical interaction potential of water-moderated arrays of cylinders of, 17: 11460 (TID-17633)
$BrF_3-UF_6$, vapor pressure equilibrium, 17: 10595 (TID-15770)
**URANIUM FOILS**
preparation, 17: 11257(R) (EURAEC-464)
radiation damage, 17: 11257(R) (EURAEC-464)
rolling, 17: 11257(R) (EURAEC-464)
**URANIUM(IV) IONS**
determination in sodium tripolyphosphate medium by controlled-potential coulometric titration, 17: 10545
**URANIUM(VI) IONS**
determination in sodium tripolyphosphate medium by controlled-potential coulometric titration, 17: 10545
elution from resins, effects of pH on, 17: 10660
**URANIUM ISOTOPES U-233**
separation from thorium-228, 17: 10246(R) (ORNL-TM-403)
spectral analysis of, 17: 11670
**URANIUM ISOTOPES U-234**
separation from plutonium-238 by anion exchange, 17: 10239(R) (MLM-1140)
spectral analysis of, 17: 11670
**URANIUM ISOTOPES U-235**
alpha particles from, mean charge of, 17: 11760
critical concentrations in aqueous solutions, 17: 11303(R) (HW-75228)
determination in uranium by emission spectroscopy, 17: 10971
determination in uranium using echelle grating spectrograph, 17: 10970
fission resonance integral, 17: 11979(R) (DP-805)
neutron absorption by, in reactor fuel, 17: 11629 (TID-15884)
neutron fission of, iodine-135 and tellurium-135 yields in thermal, 17: 11746
**URANIUM ISOTOPES U-236**
determination in uranium by emission spectroscopy, 17: 10971
kinetic energy deficit of, for fission, 17: 11646 (UCRL-10193)
**URANIUM ISOTOPES U-238**
determination in uranium by emission spectroscopy, 17: 10971
deuteron fission of kinetic energy release in 23 Mev, 17: 11646 (UCRL-10193)
neutron interactions at 6.7 ev at low temperatures, resonant shape of, 17: 11655
neutron resonance integrals in metal and oxide, 17: 11667
neutron resonance integrals of, equivalence relations for, 17: 11668
neutron resonance integral, 17: 11979(R) (DP-805)
proton fission at 0.1 to 6.2 Bev, excitation functions and nuclear charge dispersion in, 17: 11725
proton fission at 0.5 to 6.2 Bev, cross section and recoil studies of, 17: 11726
spectral analysis of, 17: 11670
**URANIUM LEACH SOLUTIONS (CARBONATE)**
processing by ion exchange, 17: 10769
**URANIUM NITRIDES**
properties of, technical progress review, 17: 11126
**URANIUM(IV) OXIDE COMPACTS**
preparation of thin, by sintering, 17: 11167 (NP-12228)
radiation effects on microstructure of rods, 17: 11260 (HW-SA-2650)
**URANIUM(IV) OXIDE POWDERS**
compaction by vibration, 17: 11108(T,R) (EURAEC-307)
fabrication by cold and hot swaging, 17: 11149 (CEND-153(Vol.I)(p.125-35))
fabrication by ultrasonic compaction, 17: 11162 (CEND-153(Vol.II)(p.163-94))
fabrication by vibratory compaction, pneumatic methods for, 17: 11145 (CEND-153(Vol.I)(p.45-59))
fabrication by vibratory compaction and swaging, 17: 11150 (CEND-153(Vol.I)(p.137-47))
fabrication of, conference on, Windsor, Conn., Nov. 30 to Dec. 1, 1961, Vol. I., 17: 11141 (CEND-153(Vol.I))
fabrication of, conference on, Windsor, Conn., Nov. 30 and Dec. 1, 1961, Vol. II, 17: 11153 (CEND-153(Vol.II))
fabrication of, control of hydrogen and moisture in, 17: 11158 (CEND-153(Vol.II)(p.101-14))
fabrication of, economic evaluation of methods for, 17: 11142 (CEND-153(Vol.1)(p.3-10))
fabrication of, particle-size relationships in packing for, 17: 11147 (CEND-153(Vol.I)(p.75-83))
fabrication techniques for, 17: 11143 (CEND-153(Vol.I)(p.11-21))
properties of compacted, 17: 11156 (CEND-153(Vol.II)(p.67-76))
radiation effects on vibrationally compacted and swaged, 17: 11154 (CEND-153(Vol.II)(p.3-38))
radiation effects on compacted, 17: 11155 (CEND-153(Vol.II)(p.39-65))
**URANIUM OXIDE SLURRIES**
in potassium–sodium alloy, properties as potential fuel, 17: 11077 (ANL-6644)
**URANIUM OXIDES**
chlorination, 17: 10519(T,R) (EURAEC-460)
particulate production and entrainment, 17: 10851(R) (HW-73337(p.158-237))
properties of, technical progress review, 17: 11126
separation from unirradiated fuel elements by fluoride volatility, 17: 10728 (BNL-6148)
$PuO_2-UO_2$, radiation effects, 17: 11117(T,R) (EURAEC-491)
$PuO_2-UO_2$, thermal expansion, 17: 11203(T) (EURAEC-434)
$SiO_2-UO_2$, phase diagram of, 17: 10641
$ThO_2-UO_2$, criticality and exponential studies of water-moderated lattices of, 17: 11938 (BAW-1257)
$ThO_2-UO_2$, fabrication, 17: 11109(T,R) (EURAEC-338)
$ThO_2-UO_2$, fabrication, 17: 11111(T,R) (EURAEC-407)
$ThO_2-UO_2$, fabrication, 17: 11967(T,R) (EURAEC-499)
$ThO_2-UO_2$, reactivity studies of, 17: 11109(T,R) (EURAEC-338)
$ThO_2-UO_2$, reactivity calculations for, 17: 11111(T,R) (EURAEC-407)
$ThO_2-UO_2$, reactivity effects of long-term irradiation of, 17: 11967(T,R) (EURAEC-499)
$UO_2-ZrO_2$, radiation effects on, at high burnup, 17: 11270 (WAPD-T-1455)
**URANIUM OXIDES (CLAD)**
development and testing, 17: 11955(R) (ORNL-3372)
relations of burn-up and melting to fuel-cladding interaction, 17: 11086(R) (GEAP-3771-4)
**URANIUM OXIDES (STAINLESS STEEL CLAD)**
design and fabrication of high-power density prototype, 17: 11945(R) (GEAP-4096)
fabrication by cold swaging, 17: 11152 (CEND-153(Vol.I)(p.163-9))
fabrication by vibratory compaction and cold swaging, 17: 11151 (CEND-153(Vol.I)(p.149-62))
fabrication by vibro-swaging process, 17: 11164(R) (EURAEC-412)
fabrication of, for BONUS prototype superheater, 17: 11165 (GNEC-179)
failure in reactors, 17: 11157 (CEND-153(Vol.II)(p.77-99))
**URANIUM OXIDES (Zr ALLOY CLAD)**
fabrication by cold swaging, 17: 11152 (CEND-153(Vol.I)(p.163-9))
fabrication by vibratory compaction and cold swaging, 17: 11148 (CEND-153(Vol.I)(p.89-124))
fabrication by vibro-swaging process, 17: 11164(R) (EURAEC-412)
failure in reactors by internal hydriding of Zircaloy-2 sheaths of, 17: 11157 (CEND-153(Vol.II)(p.77-99))
**URANIUM(IV) OXIDES**
additive effects on reduction of uranium trioxides by ammonia, 17: 10726
coating with niobium, 17: 11116 (EURAEC-487)
color and stoichiometry in, correlation of, 17: 11327 (TID-15759)
criticality and exponential studies of water-moderated lattices of, 17: 11938 (BAW-1257)
dissolution of pellets by nitric acid, effects of nitrates on rate, 17: 10246(R) (ORNL-TM-403)
extrusion and sintering in cracked ammonia, 17: 11159 (CEND-153(Vol.II)(p.115-29))
extrusion and sintering, 17: 11161 (CEND-153(Vol.II)(p.135-54))
fabrication by powder compaction, review, 17: 12013

fabrication by vibratory compaction, 17: 11146 (CEND-153(Vol.I) (p.61-74))
irradiation testing, research program, 17: 10249(T,R) (EURAEC-301)
neutron resonance integrals in, 17: 11668
neutron resonance integrals in, 17: 11667
oxidation, 17: 10519(T,R) (EURAEC-460)
oxidation to $U_3O_8$, 17: 11084(R) (EURAEC-388)
physico-chemical properties of extruded, 17: 11160 (CEND-153(Vol.II) (p.131-4))
properties as reactor fuel, investigation of, 17: 11121
properties of, for high-performance fuel elements, 17: 11086(R) (GEAP-3771-4)
radiation effects of fission fragments on, 17: 11270 (WAPD-T-1455)
radioinduced expansion, effects of power output, 17: 11256 (CRFD-1119)
separation from plutonium, 17: 10737 (NBL-189)
sintering of dense, 17: 11084(R) (EURAEC-388)
sintering, research program, 17: 11107(T,R) (EURAEC-5(Rev.))
sintering, temperature for start of, 17: 10249(T,R) (EURAEC-301)
surface energies of, theoretical estimation of, 17: 11217
swaging of sintered, 17: 11108(T,R) (EURAEC-307)
thermal conductivity of sintered, 17: 11107(T,R) (EURAEC-5(Rev.))
thermal conductivity at low temperature to 2800°C, 17: 11117(T,R) (EURAEC-491)
thermal conductivity of swaged, 17: 11152 (CEND-153(Vol.I)(p.163-9))
thermal conductivity of swaged, 17: 11164(R) (EURAEC-412)
thermal conductivity of, effects of crystal structure, fabrication procedures, and radiation on, 17: 11258 (HW-69945)
thermal conductivity of high-density, at 2800°C, 17: 11271(T,R) (EURAEC-410)
thermal expansion, 17: 11203(T) (EURAEC-434)
Cr–Mo–$UO_2$, radiation effects on stainless steel-clad, 17: 11254 (BMI-1608)
Nb–$UO_2$, radiation effects on niobium-clad, 17: 11254 (BMI-1608)
$PuO_2$–$UO_2$, radiation effects, 17: 11154 (CEND-153(Vol.II)(p.3-38))
$PuO_2$–$UO_2$, sintering, 17: 11108(T,R) (EURAEC-307)
$ThO_2$–$UO_2$, extrusion, 17: 11161 (CEND-153(Vol.II)(p.135-54))
$ThO_2$–$UO_2$, fabrication by vibratory compaction, 17: 11146 (CEND-153 (Vol.I)(p.61-74))
$ThO_2$–$UO_2$, preparation for vibratory compaction by sol-gel process, 17: 11144 (CEND-153(Vol.I)(p.23-38))
$ThO_2$–$UO_2$, radiation effects, 17: 11154 (CEND-153(Vol.II)(p.3-38))
$ThO_2$–$UO_2$, radiation effects, 17: 11155 (CEND-153(Vol.II)(p.39-65))

**URANIUM(IV-VI) OXIDES**
analysis for impurities by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
ethylene polymer-$U_3O_8$, fabrication of reactor fuel elements of, 17: 12027
fabrication and properties of, in glass fuel elements, 17: 11102(R) (NYO-9735)

**URANIUM(VI) OXIDES**
preparation by calcination of uranyl nitrate, 17: 10723 (HW-SA-2433)
reduction by ammonia at 300 to 425°C, 17: 10725
reduction by ammonia, effects of admixtures on, 17: 10726
reduction to uranium dioxide in rotary furnaces, 17: 11084(R) (EURAEC-388)

**URANIUM PHOSPHIDES**
preparation and properties of, 17: 11935(R) (ANL-6658)

**URANIUM SILICIDES**
preparation and properties of, 17: 11935(R) (ANL-6658)

**URANIUM SULFIDES**
preparation and properties of, 17: 11935(R) (ANL-6658)
properties of, technical progress review, 17: 11126
vaporization and thermodynamic properties, 17: 10598 (TID-15796)

**URANIUM SYSTEMS**
Al–Si–U, mechanical properties and structure, 17: 11096(R) (NMI-7256)
C–U, fabrication and irradiation testing, 17: 11110(T,R) (EURAEC-387)
H–U, calculations of integral and partial thermodynamic functions for, 17: 10607 (UCRL-10189)
U–UC, fabrication and sintering, 17: 11118(T,R) (EURAEC-496)

**URANYL ACETATES**
incorporation in emulsions, 17: 11039

**URANYL CHLORIDES**
sensitization of photodecomposition of organic acids, 17: 10697

**URANYL IONS**
charge and radius effects of hydrated, on radiation stability of ion exchange resins, 17: 10719
electrochemical behavior of, effects of sulfate and thiocyanate on, 17: 10541(T,R) (EURAEC-400)

**URANYL NITRATES**
conversion to uranium trioxide by calcination, development of process control by simulation techniques, 17: 10723 (HW-SA-2433)
separation from nitric acid by solvent extraction, mathematical model for, 17: 10511(R) (ORNL-3320(p.56-82))
solvent extraction by tributyl phosphate, temperature dependence of, 17: 10770
$A(NO_3)_3$–$HNO_3$–$UO_2(NO_3)_2$–$H_2O$, phase diagrams, 17: 10616
$HNO_3$–$UO_2(NO_3)_2$–$H_2O$, phase equilibrium in, 17: 10615
kerosene–TBP–$UO_2(NO_3)_2$, analysis for free acidity, design of meter for, 17: 10972

**URANYL SULFATES**
radiolysis of aqueous, gas bubble nucleation in, 17: 11952 (NAA-SR-7086)
separation by solvent extraction using tri-n-octylamine, effects of benzene, carbon tetrachloride, and chloroform on, 17: 10756

**URINE**
analysis for gross radioactivity, radiometric, 17: 10525 (ANL-6637 (p.23-8))
analysis for plutonium-239 as an estimate of body burden, 17: 10524 (ANL-6637(p.13-21))
analysis for plutonium, radiometric, 17: 10527 (ANL-6637(p.33-42))
analysis for radioactivity, statistical treatment of data, 17: 10869 (Y-KB-7)
analysis for thallium, spectrophotometric, 17: 10550
excretion of inhaled uranium in, mathematical treatment of data to determine exposure, 17: 10305 (HASL-120)
excretion of plutonium-239 in, relation to body burden, 17: 10340
plutonium excretion in, in man, 17: 10339
strontium-85 precipitation from, as oxalate and phosphate, 17: 10276
zinc distribution and turnover in, in rats, tracer study, 17: 10275

**UTERUS**
radiotherapy of carcinoma of cervix of, complications from, 17: 10496
radiotherapy of cervical carcinoma of, dosimetry of vaginal smear in, 17: 10259

# V

**VACUUM PUMPS**
design and operation of getter-ion type, 17: 10944

**VACUUM SEALS**
design, 17: 11798(R) (TID-17221)

**VALERIC ACID**
decomposition of, uranyl sensitized photo-, 17: 10697

**VALVES**
design of high-pressure leak-proof needle, 17: 10889 (AD-252467)
development of blast-closure, for bomb shelters, 17: 10776 (NP-12454)
development of, for use in radiation-resistant pneumatic systems, 17: 10774(R) (GDC-63-001)

**VAN ALLEN RADIATION BELTS**
particle density in outer, relation to F-layer critical frequencies, 17: 11453

**VAN DE GRAAFF ACCELERATORS**
target preparation and contamination, 17: 10849(R) (HW-73337(p.29-76))

**VANADIUM**
determination in aluminum, x-ray spectroscopic, 17: 10571
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
dissolution rate in liquid aluminum, 17: 10577 (ANL-FGF-292)
neutron elastic and inelastic scattering by, cold, 17: 12032
separation from metal ionic mixtures, electrochromatographic, 17: 10753
spectra of, atomic absorption, 17: 10549

**VANADIUM ALLOYS**
Al–Ti–V, mechanical properties, 17: 11099(R) (NP-12475)
Al–Ti–V, phase transformations kinetics in, 17: 11248
Mo–Nb–V–Zr, extrusion of tubing from, optimization studies, 17: 11140(R) (AMC-TR-7-775(VII))

Nb–V, properties of welded, 17: 11242
Nb–V–Zr, phase studies, 17: 11108(T,R) (EURAEC-307)
Tc–V, phase studies on, 17: 11220
V–Zr, phase studies of, 17: 11213
V–Zr, phase studies, 17: 11204(T,R) (EURAEC-444)
**VANADIUM BORIDES**
bibliography on preparation and properties of, 17: 10579 (ASD-TDR-62-873)
**VANADIUM CARBIDES**
formation in vanadium steel, 17: 11209
superconductivity of, negative results, 17: 11391
thermoelectric properties at 1600 to 2130°K, 17: 11436
**VANADIUM ISOTOPES V-51**
energy levels in, nuclear g factor of, 17: 11700
gamma reactions ($\gamma,\alpha$) with, alpha spectra from, 17: 11678
neutron reactions (n,$\alpha$) at 14.5 Mev, cross sections for, 17: 11614 (BNL-6044)
**VANADIUM STEEL**
carbide formation in, 17: 11209
**VAPOR PRESSURE**
equations for, graphical method for determining nonlinear constant in, 17: 10620
**VAPORIZATION**
thermodynamics of suboxide, 17: 10645
**VEHICLES**
design of ORNL mobile radiation laboratory, 17: 10877
**VELA PROJECT**
instrumentation development for, 17: 10819(R) (AD-278217)
seismic data for on-site inspection, 17: 10238(R) (AD-278378)
seismic measurements from MAD event, 17: 10245 (NP-12524)
**VIRUSES**
encephalomyelitis effects on bone marrow and lymph system in guinea pigs compared with x radiation, 17: 10427
infection of mice with mousepox, effects of deuterium oxide on, 17: 10285
plaquing efficiency of CHAT, effects of water-*d*, at 40°C with limited thermal exposure ratios, 17: 10290
**VISION**
function of rods in, compartment theory for theory of, mathematical representation of compartment, 17: 11028
**VITAMIN A**
determination in blood, feces, and tissues by liquid scintillation of tritium, 17: 10552
**VITAMIN $B_{12}$**
radiodecomposition of, external and internal gamma, 17: 10718
**VOLATILITY SEPARATION PROCESSES**
development, 17: 10741(R) (ORNL-TM-313)
use of fluidized beds in reprocessing solid reactor fuels, 17: 10730 (BNL-6195)
**VOLTAGE REGULATORS**
design of, for image intensifier tubes, 17: 10907 (TID-15860)

# W

**WASPALOY**
brazing and welding of, criteria for, 17: 11163 (DMIC-181)
**WASTE DISPOSAL**
ground, monitoring of ground waters in Hanford Area, 17: 10822 (HW-SA-2566)
**WASTE PROCESSING**
bibliography on decontamination of radioactive water, 17: 12043 (NP-12482)
by calcination, development, 17: 10741(R) (ORNL-TM-313)
by coagulation, efficiency for Hanford Production Reactor coolant effluent decontamination, 17: 12041 (HW-SA-2192)
calcination and fixation in solids, conference on, Washington, D. C., February 1 and 2, 1962, 17: 12044 (TID-7646)
calcination in, development and performance of fluidized beds for, 17: 12045 (TID-7646(p.3-19))
calcination of aqueous wastes in molten sulfur, 17: 12046 (TID-7646(p.20-36))
calcination of aqueous wastes, development of pot method for, 17: 12049 (TID-7646(p.52-68))
calcination of aqueous wastes, development of radiant spray method for, 17: 12051 (TID-7646(p.83-93))
calcination of wastes, development of pot process for, 17: 12050 (TID-7646(p.69-82))
evaporation, design and characteristics of installations for, 17: 12053
fixation of Purex and TBP-25 wastes in glass, 17: 10246(R) (ORNL-TM-403)
fixation of wastes in phosphate glass, 17: 12048 (TID-7646(p.43-51))
fixation of wastes in ceramic sponges, 17: 12052 (TID-7646(p.94-101))
methods of, review, 17: 12054
precipitation of strontium from IWW Purex waste, 17: 10246(R) (ORNL-TM-403)
sorption of cesium-137 on zeolite, effects of gamma leakage on thermal conditions for, 17: 12040 (HW-74712)
**WASTE SOLUTIONS**
clarification, effects of carbonate and phosphates on hardness of effluent, 17: 10246(R) (ORNL-TM-403)
corrosive effects of Purex, on stainless steel, 17: 10246(R) (ORNL-TM-403)
decontamination, 17: 10851(R) (HW-73337(p.158-237))
hazards, origin, and treatment, 17: 12054
precipitation of calcium and magnesium from low-level, 17: 10246(R) (ORNL-TM-403)
**WATER**
adsorption by quartz under benzene, effects of hysteresis angles on, 17: 11091(R) (MITS-49)
air-$H_2O$, heat transfer in flows through parallel-rod arrays, 17: 10812
analysis for deuterium, falling-drop, 17: 10566
boiling burnout in flow through vertical annuli, 17: 10789 (AE-100)
boiling burnout in, investigation of critical, 17: 10807(T,R) (EURAEC-449)
boiling of subcooled, burnout heat flux limits in annulus, 17: 11979(R) (DP-805)
corrosive effects on Zircaloy-2 at 360°C, 17: 11097(R) (NMI-7257)
corrosive effects on annealed Zircaloy-2 at 550°F, 17: 11132 (KAPL-M-AA-4)
decontamination of radioactive, bibliography on, 17: 12043 (NP-12482)
determination in peat by neutron stopping, 17: 10559
dissolution of irradiated sodium chloride in, quenching effects of oxygen on luminescence from, 17: 10612
effects on molecular weight distribution in radioinduced polymerization of $\alpha$-methylstyrene, 17: 11285
heat transfer in small-diameter high-pressure tubes, 17: 10806(T) (AEC-tr-5602)
measurement on surfaces, design of neutron device for, 17: 10925
neutron scattering by, thermal, 17: 11589 (HW-75526)
neutron scattering in, comparison of Nelkin's kernel with experiment, 17: 11303(R) (HW-75228)
neutron transport in, measurement of extrapolation lengths for, 17: 11600 (WAPD-T-1490)
physiochemical properties of oxygen-16 and -18 labeled, 17: 10657
purification of radioactive, by ion exchange, 17: 10710
radiolysis mechanism, 17: 10509(R) (ORNL-3320(p.30-46))
radiolysis of, mechanism of hydrogen peroxide formation in, 17: 10686
reactions with uranium carbide, 17: 10246(R) (ORNL-TM-403)
self-diffusion in, at 25°C, effects of electrolytes and heavy water on, 17: 10613
sorption by intestine and stomach in dogs, effects of centimeter band radio waves on, 17: 10315
$Al(NO_3)_3$–$HNO_3$–$UO_2(NO_3)_2$–$H_2O$, phase diagrams, 17: 10616
$D_2O$–$H_2O$, analysis for deuterium and hydrogen, 17: 10240(R) (NP-12208)
$HNO_3$–$UO_2(NO_3)_2$–$H_2O$, phase equilibrium in, 17: 10615
$H_2O$–$D_2O$, proton magnetic resonance shifts in, 17: 11342
**WATER-*d*,**
determination in water, falling-drop, 17: 10566
effects on plaquing efficiency of polio virus at 40°C with limited thermal exposure ratios, 17: 10290
neutron streaming in pipes, 17: 11588 (AE-98)
preparation by isotopic exchange, 17: 11058
production by cascade electrolysis, 17: 11056(T) (CEA-tr-A-1159)
protective effects against mousepox in mice, 17: 10285

self-diffusion effects of, on water at 25°C, 17: 10613
$D_2O$–$H_2O$, analysis for deuterium and hydrogen, 17: 10240(R) (NP-12208)
$H_2O$–$D_2O$, proton magnetic resonance shifts in, 17: 11342
**WATER COOLED REACTORS**
design of marine steam-cooled light-water-moderated, 17: 12006
process instrumentation for, review, 17: 10996
reactivity fluctuations in boiling, mean-square minimization of, 17: 12008
**WATER MODERATED REACTORS**
design of marine steam-cooled, 17: 12006
**WATER PURIFICATION EQUIPMENT**
evaluation, 17: 10850(R) (HW-73337(p.77-157))
**WATER SUPPLIES**
analysis for strontium x-ray fluorescence spectrometric, 17: 10553
**WATER VAPOR**
ionization effects in nitrogen-filled chambers, 17: 11047
reactions with lithium at 20 to 45°C, 17: 10622
**WELDED JOINTS**
ductility of, on high-strength steels, 17: 11113(T,R) (EURAEC-430)
mechanical shock resistance in thick, 17: 11171(T,R) (EURAEC-330)
**WELDING**
development for reactor materials, review of, 17: 11123
filler products for, performance of molybdenum and nickel alloys for, 17: 11171(T,R) (EURAEC-330)
of INOR-8 by shielded consumable-electrode process, 17: 11169 (Y-1409)
of metals, review of, 17: 11166 (HW-SA-2527)
stresses from rising vertical process of, analysis of residual, 17: 11172(T,R) (EURAEC-391)
stresses in rising vertical processes of, residual stressed from, 17: 11173(T,R) (EURAEC-446)
techniques for, development of, 17: 11130
**WELDING RODS**
performance of steel, effects of additives on, 17: 11171(T,R) (EURAEC-330)
**WELDS**
testing of, validity of requirements for nondestructive, 17: 11168 (TID-15756)
**WELL LOGGING**
development of radiometric, 17: 10243 (NP-12381)
equipment for measuring temperature and vertical currents, 17: 10851(R) (HW-73337(p.158-237))
fission product transport through soil, 17: 10820 (BNL-6554)
neutron age equations for, fast, 17: 10833
probe design for gamma and neutron, 17: 10836
techniques in, 17: 10842
**WHEAT**
radiation effects on flour flavor and odor, germination, respiration, and surface molds, cathode, 17: 10374
radiation effects on species with different ploidy, x, 17: 10381
radiation effects on embryonic-endo sperm ratio in, gamma, thermal neutron, and x, 17: 10386
radiation effects on growth and survival of, comparison with effects of mutagenic agents, 17: 10388
radioinduced chromosomic aberrations in "Cappelli", 17: 10389
radioinduced mutations in "Cappelli" durum, 17: 10390
**WOOD**
stress analysis of balsa, 17: 11937(R) (ARF-4132-16)

## X

**X RADIATION**
accidental exposure of dentist to, effects of, 17: 10872
biological effects on kidneys and submaxillary glands of rats in presence of cortisone, 17: 10470
biological effects on chickens, comparison with gamma rays, 17: 10471
biological effects in mice, effects of linear energy transfer on early response, 17: 10358 (BNL-6575)
biological effects on diploid and hexaploid species of *Avena*, 17: 10457
cancerogenic effects on lymph system in mice, 17: 10406
carcinogenic effects on tubercular lupus, 17: 10441
chromosomal aberration gradients induced in *Tradescantia* anthers by, yields in, 17: 10454
chromosome rearrangement induced by, in translocated heterozygotes of *Tipula oleracea*, 17: 10402
de-excitation effect of, 17: 11289(T)
effects of cranial, on fixated behavior and maze performance in rats, 17: 10430
effects of exposure of testes to, on weight of offspring in swine, 17: 10414
effects of on children exposed *in utero*, 17: 10875
effects on antibody formation in mice, tracer study, 17: 10255(R) (TID-17648)
effects on barbiturate response in rats, effects of methysurgide, 5-hydroxytryptamine, and cysteamine, 17: 10418
effects on barley, relation of embryo structure, node position, planting depth and tillering to, 17: 10453
effects on blood coagulation in man, occupational, 17: 10446
effects on bone marrow and lymph system in guinea pigs compared with encephalomyelitis virus, 17: 10427
effects on "brown spot" character in Drosophila, 17: 10379
effects on catalase accumulation in conidia of *Aspergillus niger*, 17: 10397
effects on cell division in pea seedlings, 17: 10359 (HW-SA-2606)
effects on cellular and nuclear growth in *Paramecium aurelia*, 17: 10408
effects on collagen fraction in atrophic muscle, 17: 10465
effects on diluted aqueous solutions, 17: 10717
effects on DNA synthesis in peripheral blood cells in rabbits, 17: 10291
effects on embryo-endo sperm ratios in seeds, 17: 10386
effects on enzyme systems in rat liver, 17: 10479(R) (NP-12251(p.12-21))
effects on enzyme systems in rat liver, 17: 10478(R) (NP-12251 (p.1-11))
effects on extracts and fragments of chloroplasts, 17: 10458
effects on fitness factors of Drosophila populations, 17: 10384
effects on fumarase activity in *Tetrahymena pyriformis GL* during cell division, 17: 10409
effects on glomerular lesions in kidneys in mice, pathogenesis of whole-body, 17: 10433
effects on growth and survival of durum wheat, comparison with effects of mutagenic agents, 17: 10388
effects on immunity to *Trichinella spiralis* infection in mice, 17: 10424
effects on immunological recovery in mice, role of thymus in, 17: 10412
effects on islet-cell tumors in pancreas in rats, 17: 10432
effects on lipid metabolism in leukocytes, 17: 10365(R) (TID-17692)
effects on metaphase/prophase ratio in man and mice, 17: 10411
effects on mongolism occurrence, maternal exposure, 17: 10436
effects on mortality of mice infected with *Trichinella spiralis*, 17: 10431
effects on nucleic acid and protein metabolism in barley seedlings, 17: 10456
effects on prepyriform electrical activity in rats, whole-body, 17: 10373
effects on Purkinje cells in animals, 17: 10460
effects on response of rats to plutonium, 17: 10318
effects on response to electrical excitation in isolated nerves, 17: 10417
effects on ribonucleic acid metabolism in nervous system, 17: 10356 (BNL-6546)
effects on skin grafting in rabbits, role of antibodies in, 17: 10425
effects on thymidine metabolism in intestine, effects of AET treatment, 17: 10486 (TID-15931)
effects on toxicity of praseodymium nitrate in rats, 17: 10484(R) (NP-12251(p.90-8))
effects on ultrastructure of neurons of Gasser ganglion in rats, 17: 10461
effects on urinary excretion of sodium and potassium in rats, 17: 10463
effects on wheat species of different ploidy, 17: 10381
emission in polonium-210 alpha decay, 17: 11616 (BNL-6166)
fluorescence excitation in transition elements, 17: 11368
genetic effects in Drosophila, 17: 10415
genetic effects on maize under different physiological conditions, 17: 10380
genetic effects on adult male mosquitoes, 17: 10385
genetic effects on *Nicotiana tabacum*, polygenic mutability, 17: 10387
genetic effects on sex-linked recessive lethals in Drosophila, 17: 10392
genetic effects on *Vicia sativa* L, 17: 10395
induction of sterilization in female and male chick embryos, 17: 10375
lethal effects on rats, morning and night exposure, 17: 10467

lethal effects on thymocytes, effects of cystamine on, 17: 10487
lethal effects on rats at various intervals after injection of cysteamine, 17: 10488
lethal effects on guinea pig cells cultivated *in vitro*, 17: 10383
leukemia induced in rats by methylcholanthrene and, transmission of, 17: 10258
mutagenic effects on "Cappelli" durum wheat, 17: 10390
mutagenic effects on tomato seeds, comparison with spontaneous mutability, 17: 10391
mutagenic effects on Drosophila, 17: 10393
mutagenic effects on maize seedlings, effect of temperature on, 17: 10394
mutation induced in *Medicago sativa L.*, cytogenetics of single-leaf, 17: 10398
mutation induced in *Medicago sativa L.*, morphology of single-leaf, 17: 10399
physiopathological effects on brain in rats, 17: 10459

**X-RAY-ABSORPTION ANALYSIS**
survey of theory and operation, 17: 10947

**X-RAY BEAMS**
delineation of diagnostic, circular and elliptic, 17: 10273
intensity measurement of, design of apparatus for, 17: 10975

**X-RAY-DIFFRACTION ANALYSIS**
of irradiated uranium, design of unit for, 17: 10894 (HW-SA-2616)
survey of theory and operation, 17: 10947

**X-RAY EQUIPMENT**
hygiene in dental, 17: 10871
leakage detection in tubes, development of apparatus for, 17: 11018

**X-RAY SOURCES**
sizing targets for, 17: 11353

**X-RAY SPECTROMETERS**
development, 17: 10948

**X-RAY SPECTROSCOPY**
fluorescent, use for chemical analysis, 17: 10949
sample preparation by isoformation, 17: 10950
survey of theory and methods for chemical analysis, 17: 10947

**XENON**
buildup in high-flux reactors, design of circuits to simulate, 17: 10993
meson ($\pi^-$) reactions at 8.4 Bev/c, meson ($\pi^0$) production in, 17: 11673
origin of atmospheric, 17: 11445 (NASA-TN-D-1685)

**XENON ISOTOPES**
separation by thermodiffusion concentration distribution in tubes for, 17: 11059
separation of, effectiveness of thermal diffusion columns for, 17: 11051 (TID-15343)

**XENON ISOTOPES Xe-126**
energy levels in, structure of low-lying $2^+$, 17: 11698

**XENON ISOTOPES Xe-132**
energy levels, 17: 11685

**XENON ISOTOPES Xe-133**
diffusion from alkali metal chloride crystals during thermal annealing, 17: 10638

**XENON ISOTOPES Xe-134**
energy levels, 17: 11685

**XENON SYSTEMS**
He–Xe, characteristics of electric discharge in, 17: 11431
H–Xe, characteristics of electric discharge in, 17: 11431

# Y

**YTTERBIUM**
determination in aluminum as trace impurity, activation, 17: 10546
electron energy levels in, self-consistent wave functions for, 17: 11394
spectra of, isotope shift in λ 5556Å, 17: 10625

**YTTERBIUM HYDRIDES**
electronic structure, 17: 11329 (TID-15934)

**YTTERBIUM ISOTOPES Yb-176**
isomeric state of, 17: 11690

**YTTERBIUM SELENIDES**
thermoelectric properties of sesqui-, 17: 11292 (AD-277043)
thermoelectric properties, 17: 11296 (AD-278352)
NdSe–YbSe, thermoelectric properties, 17: 11296 (AD-278352)

**YTTERBIUM TELLURIDES**
thermoelectric properties, 17: 11296 (AD-278352)

**YTTRIUM**
binding to blood serum proteins and nucleic acids, tracer study, 17: 10307 (TID-17522)
deposition in bone, reaction mechanisms, 17: 10332
determination using diammonium-5,5′-indigo disulphonate, 17: 10568
discovery and development of, review on, 17: 10618
distribution in tissues of mice of ionic and chelated form, tracer study, 17: 10308 (TID-17542)
electric conductivity of, from electron-phonon scattering in, 17: 11221
reactions with plutonium and uranium at high temperatures, 17: 10239(R) (MLM-1140)
separation from promethium by pulsed solvent extraction, 17: 10746 (TID-15792)
spectra of, atomic absorption, 17: 10549
thermodynamic properties at high temperatures, 17: 10580 (BM-RI-6155)

**YTTRIUM ALLOYS**
Ce–Y, phase studies, 17: 11186 (DRI-2080)
La–Y, phase studies, 17: 11186 (DRI-2080)
Lu–Y, electric conductivity, 17: 11190 (IS-477)
Nd–Y, phase studies, 17: 11186 (DRI-2080)

**YTTRIUM BORIDES**
electric properties, 17: 11306 (IS-473)

**YTTRIUM DEUTERIDES**
thermodynamic properties, 17: 10597 (TID-15795)

**YTTRIUM FLUORIDES**
distribution of colloidal solutions of, in animal tissues, 17: 10443

**YTTRIUM HYDRIDES**
thermodynamic properties, 17: 10597 (TID-15795)

**YTTRIUM ISOTOPES**
determination in mixed fission products, radiochemical, 17: 10850(R) (HW-73337(p.77-157))

**YTTRIUM ISOTOPES Y-88**
production and separation of, method for, 17: 10676 (NP-12231)

**YTTRIUM ISOTOPES Y-89**
isomer yield from deuteron reactions, 17: 11634(R) (TID-17696)

**YTTRIUM ISOTOPES Y-90**
dosimetry of granules of, method for measuring, 17: 11029
histological effects on pituitary gland, 17: 10451
use of, in microspheres for cancer therapy in animals and man, 17: 10288

**YTTRIUM ISOTOPES Y-91**
use in study of movement of liquid and solid in small intestine in rats, 17: 10281

**YTTRIUM PHOSPHATES**
distribution of colloidal solutions of, in animal tissues, 17: 10443

**YTTRIUM SELENIDES**
thermoelectric properties of sesqui-, 17: 11292 (AD-277043)

**YTTRIUM SILICATES**
distribution of colloidal solutions of, in animal tissues, 17: 10443

**YTTRIUM SULFIDES**
thermoelectric properties of sesqui-, 17: 11292 (AD-277043)

**YTTRIUM TELLURIDES**
thermoelectric properties of sesqui-, 17: 11292 (AD-277043)

**YTTRIUM VANADATES**
structure of, x ray diffraction analysis of, 17: 10663

# Z

**ZINC**
analysis for arsenic using Gutzeit method, 17: 10563
determination in aluminum as trace impurity, activation, 17: 10546
determination in aluminum, x-ray spectroscopic, 17: 10571
determination in uranium(IV-VI) oxide by carrier distillation excitation, effects of graphite electrode grade on, 17: 10538 (TID-16295)
distribution and turnover in rats, tracer study, 17: 10275
distribution between anion exchange resin and aqueous chloride solutions, 17: 10588 (IA-764)
electric resistivity of, effects of lattice vacancies on, 17: 11231
electron transport phenomena in, at liquid helium temperatures, 17: 11378
separation from metal ionic mixtures, electrochromatographic, 17: 10753

**ZINC ALLOYS**
Al–Mg–Zn, temperature dependence in stress corrosion, 17: 11139

Al–Zn, effect of cold working on phase segregation in, 17: 11246
Al–Zn, high-ductile state in, 17: 11247
Cd–Mg–Zn, creep properties, 17: 11179 (AERE-M-1149)
**ZINC IONS**
separation from metal ions by extraction using 8-quinolinethiol, 17: 10768
**ZINC ISOTOPES**
production in meson ($\pi^-$) reactions, cross sections and yields for, 17: 11650 (UCRL-10531)
**ZINC ISOTOPES Zn-64**
proton scattering at 9.6 and 11.7 Mev by, differential cross sections for, 17: 11643 (UCRL-6930)
proton scattering at 6.9 Mev, 17: 11656
**ZINC ISOTOPES Zn-68**
proton reactions (p,2p) at 400 Mev to 6.2 Bev, cross sections and excitation functions for, 17: 11650 (UCRL-10531)
proton scattering at 6.9 Mev, 17: 11656
**ZINC ISOTOPES Zn-70**
proton scattering at 6.9 Mev, 17: 11656
**ZINC ISOTOPES Zn-72**
decay scheme, 17: 11723
**ZINC NITRATES**
salting-out properties in uranyl nitrate extraction from aqueous solutions, 17: 10770
**ZINC OXIDES**
additive effects on reduction of uranium trioxides by ammonia, 17: 10726
**ZINC SELENIDES**
displacement of selenium in, by electron bombardment, 17: 11320 (NP-12360)
**ZINC SULFIDE CRYSTALS**
luminescence of, chlorine-, copper-, and manganese-activated, effects of electric field on gamma, 17: 11229(T)
luminescence of copper-activated, de-excitation effect of x ray in, 17: 11289(T)
luminescence of, model for electric-field quenching of, 17: 11362
**ZINC SULFIDES**
luminescence of copper-activated, effects of coactivators on, 17: 11228(T)
**ZIRCALOY-2**
corrosion by lithiated water at 550°F, effects of annealing on, 17: 11132 (KAPL-M-AA-4)
corrosion by water at 360°C, effects of heat treatment in salt, 17: 11097(R) (NMI-7257)
corrosion of, by steam–water spray, 17: 11941(R) (EURAEC-475)
etching by cathodic arc, 17: 11089 (HW-SA-2559)
fabrication of tubes of, 17: 11979(R) (DP-805)
hydridation of, in reactors, 17: 11157 (CEND-153(Vol.II)(p.77-99))
radiation effects on mechanical properties, 17: 11129
welding of, development of thermocouples for measurements in, 17: 11105 (TID-17734)
welding to stainless steel, 17: 11084(R) (EURAEC-388)
**ZIRCONIUM**
alloying effects on chromium-nickel steel, 17: 11210
corrosion studies of, technical progress review, 17: 11129
diffusion of oxygen in, 17: 11129
electrochemical properties, 17: 10512(R) (ORNL-3320(p.83-97))
handling of, safety in, 17: 10863 (RSPP-20(Issue 1))
phase studies, 17: 11204(T,R) (EURAEC-444)
radiation effects on mechanical properties, 17: 11129
reduction of oxygen on film-covered, production of hydrogen peroxide in, 17: 10623
solubility in copper, solid, 17: 11240
transformations in, martensite, 17: 11239
Cr–$HBF_4$–HF–$HNO_3$–Zr, solvent properties for uranium–zirconium alloy, 17: 10246(R) (ORNL-TM-403)
**ZIRCONIUM ALLOYS**
handling of, safety in, 17: 10863 (RSPP-20(Issue 1))
properties, 17: 11129
ultrasonic Lamb wave propagation in Zircaloy, 17: 11304 (HW-75499)
Be–Zr, properties, 17: 11082(R) (BBC-113)
Cr–Nb–Zr, phase studies, 17: 11108(T,R) (EURAEC-307)
Cr–Zr, structural study, 17: 11108(T,R) (EURAEC-307)
Cu–Zr, age hardening and conductivity of, affect of oxidation inhibitors and purity on, 17: 11225
Cu–Zr, solid solubility of zirconium in copper in, 17: 11240
Mo–Nb–V–Zr, extrusion of tubing from, optimization studies, 17: 11140(R) (AMC-TR-7-775(VII))
Mo–Zr, beta phase stabilization in, 17: 11213
Nb–V–Zr, phase studies, 17: 11108(T,R) (EURAEC-307)
Nb–Zr, attenuation of 5- to 30-Mc elastic waves in superconducting, 17: 11400
Nb–Zr, beta phase stabilization in, 17: 11213
Nb–Zr, corrosion by liquid sodium, 17: 11935(R) (ANL-6658)
Nb–Zr, fabrication of, for mercury corrosion loop, 17: 11131 (AGC-0584-04-5)
Nb–Zr, fatigue behavior in potassium at 800°F, 17: 12036(R) (SY-5396-R3)
Nb–Zr, mechanical properties at −300 to 1200°F, 17: 11075(R) (AD-278043)
Nb–Zr, mechanical properties, 17: 11108(T,R) (EURAEC-307)
Nb–Zr, properties of welded, 17: 11242
Ni–Zr, phase studies, 17: 11204(T,R) (EURAEC-444)
Re–Zr, phase studies of, 17: 11213
Sn–Ti–Zr, creep properties at 300 to 700°C, 17: 11211
Tc–Zr, phase studies on, 17: 11220
U–Zr, dissolution, 17: 10246(R) (ORNL-TM-403)
U–Zr, processing of irradiated, 17: 10742 (ORNL-TM-447)
U–Zr, separation from unirradiated fuel elements by fluoride volatility, 17: 10728 (BNL-6148)
V–Zr, phase studies of, 17: 11213
V–Zr, phase studies, 17: 11204(T,R) (EURAEC-444)
**ZIRCONIUM BORIDES**
bibliography on preparation and properties of, 17: 10579 (ASD-TDR-62-873)
**ZIRCONIUM CARBIDES**
melting point, 17: 11201(T) (AEC-tr-5598)
physical properties, 17: 11215
thermal expansion, 17: 11110(T,R) (EURAEC-387)
NbC–TaC–ZrC, melting point, 17: 11201(T) (AEC-tr-5598)
NbC–ZrC, melting point, 17: 11201(T) (AEC-tr-5598)
TaC–ZrC, melting point, 17: 11201(T) (AEC-tr-5598)
UC–ZrC, fabrication, 17: 11311(R) (LAMS-2796)
UC–ZrC, thermoelectric properties at 1700 to 2620°K, 17: 11436
$W_2C$–ZrC, melting point, 17: 11201(T) (AEC-tr-5598)
**ZIRCONIUM DEUTERIDES**
phase studies, 17: 10578 (ANL-FGF-332)
thermodynamic properties, 17: 10597 (TID-15795)
**ZIRCONIUM HYDRIDES**
phase studies, 17: 10578 (ANL-FGF-332)
thermodynamic properties, 17: 10597 (TID-15795)
**ZIRCONIUM ISOTOPES Zr-95**
separation of, from nitric acid, efficiency of AMSCO-TBP in, 17: 10739(R) (ORNL-TM-27)
**ZIRCONIUM OXIDES**
sorptive properties for radioisotopes in water, 17: 10710
vaporization at 2300 to 2500°C, spectra of, 17: 11191(R) (NP-12483)
$UO_2$–$ZrO_2$, radiation effects on, at high burnup, 17: 11270 (WAPD-T-1455)
**ZIRCONIUM PHOSPHATES**
sorptive properties for radioisotopes in water, 17: 10710
**ZIRCONIUM SYSTEMS**
C–Nb–W–Zr, extrusion of tubing from, optimization studies, 17: 11140(R) (AMC-TR-7-775(VII))
H–Zr, calculations of integral and partial thermodynamic functions for, 17: 10607 (UCRL-10189)
H–Zr, thermal stability, 17: 11817
**ZIRFLEX PROCESS**
development of dissolution step, 17: 10743(R) (ORNL-TM-457)

# REPORT NUMBER INDEX

All reports, translations, and patents abstracted in this issue are included in this index. Each item is listed by report number; this is followed by the abstract number and a brief notation regarding public availability. The index entries show, when known, which reports are on file in the depository libraries, which reports have been published in open-literature journals (journal citation given), and which reports can be purchased (source and price). Whenever a report is identified by more than one number, cross references from secondary to primary report numbers are cited.

The report number codes apply to AEC reports unless designated otherwise. Non-AEC reports are identified by parenthetical notes after the report codes; e.g., (non-AEC), (British), (Canadian), (French). The note (Misc.) identifies those codes used for both USAEC and non-AEC reports. The report numbers for the non-AEC reports in these series are marked with an asterisk (*). Patents are listed under the heading "PATENTS"; the country of origin is included in parentheses.

A comprehensive listing of both AEC and non-AEC report codes is contained in TID-85(2nd Rev.), *Report Number Series Used by the Technical Information Service in Cataloging Reports*. March 1960, $2.75 (OTS), and supplement, August 1960, $0.50 (OTS).

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## Abbreviations Used in Availability Column

| | |
|---|---|
| AECL | For sale by Atomic Energy of Canada Ltd., Chalk River, Ontario, Canada. |
| BIS | For sale by the British Information Service, 45 Rockefeller Plaza, New York 20, N. Y. |
| Dep. | AEC reports: Full-size copy is on deposit in the depository libraries both in and outside the United States. These reports are also for sale by Microcard Editions, Inc., Accounting and Shipping Department, West Salem, Wisconsin.<br>Non-AEC reports: Full-size copy on deposit in the depository libraries in the United States only. |
| Dep.(mc) | Same as for Dep., except copy is in Microcard form. |
| DSIR | For sale by the Department of Scientific and Industrial Research, Lending Library Unit, 20 Chester Terrace, London, N. W. 1, England. |
| DTI Extension | Available from the U. S. Atomic Energy Commission, Division of Technical Information Extension, P. O. Box 62, Oak Ridge, Tennessee. |
| GPO | For sale by the Superintendent of Documents, Government Printing Office, Washington 25, D. C. |
| HMSO | Her Majesty's Stationery Office, London. |
| IAEA | Available from the International Atomic Energy Agency. |
| JCL | For sale by the Special Libraries Association Translation Center, John Crerar Library, 86 E. Randolph Street, Chicago 1, Illinois. |
| NRC | For sale by the National Research Council of Canada, Ottawa, Ontario, Canada. |
| OTS | For sale by the Office of Technical Services, Department of Commerce, Washington 25, D. C. |
| USGS | Available free-of-charge from the U. S. Geological Survey, Washington 25, D. C. |

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| Report No. | Abstract No. | Availability |
|---|---|---|
| **NUMERICAL** | **(Misc.)** | |
| 62GL132* | 17-10788 | |
| **AAEC-E–** | **(Australian)** | |
| 101 | 17-11933 | Dep.(mc) |
| **AAEC-TM–** | **(Australian)** | |
| 136 | 17-11603 | Nucl. Sci. Eng. 14: 346-57(1962) |
| 161 | 17-10498 | Dep.(mc) |
| 164 | 17-11586 | Dep.(mc) |
| **ACNP–** | | |
| 62028 | 17-11977 | Dep.(mc); $4.60(fs), $1.43(mf) OTS |
| **AD–** | **(Misc.)** | |
| 252467* | 17-10889 | |
| 267978* | 17-11829 | See ASD-TR-61-179(Vol.I) |
| 273961* | 17-11826 | $2.60(OTS) |
| 277005* | 17-11298 | See AFCRL-62-456 |
| 277043* | 17-11292 | |
| 277122* | 17-11293 | $14.50(OTS) |
| 277223* | 17-11294 | $5.60(OTS) |
| 277373* | 17-11828 | See AFCRL-62-63 |
| 277387* | 17-11611 | Nuovo Cimento (10), 26: 1221-44(1962) |
| 277461* | 17-11953 | See NARF-61-45R |
| 277601* | 17-11827 | $8.10(OTS) |
| 277706* | 17-11810 | See USASRDL-TR-2257 |
| 277713* | 17-11295 | $2.60(OTS) |
| 278043* | 17-11075 | $1.60(OTS) |
| 278073* | 17-11830 | See D1-82-0166 |
| 278098* | 17-11836 | See RADC-TDR-62-186 |
| 278150* | 17-10773 | See ASD-TDR-62-428 |
| 278179* | 17-11464 | See AFOSR-2978 |
| 278204* | 17-12033 | See ASD-TDR-62-591 |
| 278217* | 17-10819 | |
| 278240* | 17-11612 | See AFOSR-2975 |
| 278263* | 17-11490 | See RM-3221-PR |
| 278352* | 17-11296 | $4.60(OTS) |
| 278371* | 17-11076 | $5.60(OTS) |
| 278378* | 17-10238 | |
| 283955* | 17-11263 | See NP-12361 |
| 283956* | 17-11590 | See NP-12368 |
| 284014* | 17-10856 | See NP-12351 |
| 284016* | 17-12034 | See NP-12353 |
| 284017* | 17-11318 | See NP-12357 |
| 284018* | 17-11320 | See NP-12360 |
| 284020* | 17-11006 | See NP-12376 |
| 288221* | 17-10477 | See NP-12251 |
| 292257* | 17-11829 | See ASD-TDR-62-756 |
| **AE–** | **(Swedish)** | |
| 88 | 17-11587 | |
| 92 | 17-11895 | Dep.(mc) |
| 93 | 17-11896 | Dep.(mc) |
| 94 | 17-11897 | Dep.(mc) |
| 95 | 17-11297 | Dep.(mc) |
| 96 | 17-10576 | Dep.(mc) |
| 98 | 17-11588 | Dep.(mc) |
| 100 | 17-10789 | Dep.(mc) |
| **AEC-tr–** | | |
| 5484 | 17-11998 | Dep.(mc); $2.60(fs), $0.98(mf) JCL |
| 5555 | 17-10813 | Dep. |
| 5581 | 17-10881 | Dep.(mc); $2.60(fs), $0.98(mf) JCL |
| 5598 | 17-11201 | $1.60(fs), $0.80(mf) JCL |
| 5600 | 17-10312 | Dep.(mc); $1.60(fs), $0.80(mf) JCL |
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| 1640 | 17-11939 | See CRL-75 |
| 1664 | 17-11256 | See CRFD-1119 |
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| 62-63 | 17-11828 | $11.50(OTS) |
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| 2975* | 17-11612 | $1.60(OTS) |
| 2978* | 17-11464 | $2.60(OTS) |
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| **AGN-TM–** | | |
| 399 | 17-11978 | Dep.; $0.50(OTS) |
| **AID-Report–** | **(Non-AEC)** | |
| 61-10 | 17-10889 | See AD-252467 |
| **AMC-TR–** | **(Non-AEC)** | |
| 7-775(VII) | 17-11140 | |
| **ANL–** | | |
| 6612 | 17-11299 | Dep.; $2.60(fs), $1.07(mf) OTS |
| 6634 | 17-10890 | Dep.; $1.25(OTS) |
| 6637 | 17-10522 | Dep.; $2.25(OTS) |
| 6644 | 17-11077 | Dep.; $1.75(OTS) |
| 6652 | 17-10772 | Dep.; $0.50(OTS) |
| 6658 | 17-11935 | Dep.; $2.00(OTS) |
| 6672 | 17-11936 | Dep.; $1.25(OTS) |
| **ANL-FGF–** | | |
| 292 | 17-10577 | Dep.(mc); $2.60(fs), $0.86(mf) OTS |
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| 332 | 17-10578 | Dep.(mc); $2.60(fs), $0.98(mf) OTS |
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| 335 | 17-10814 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 337 | 17-11180 | Dep.(mc); $9.60(fs), $3.80(mf) OTS |
| 339 | 17-10891 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
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| 345 | 17-11181 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 349 | 17-11363 | Phys. Chem. Solids 23: 1825-7(1962) |
| 352 | 17-11220 | J. Less-Common Metals 4: 558-63(1962) |
| **ANLAD–** | | |
| 72 | 17-11799 | See TID-17617 |
| 73 | 17-11801 | See TID-17652 |
| **ARF–** | **(Misc.)** | |
| 1164-27 | 17-10880 | Dep.; $2.25(OTS) |
| 4132-16 | 17-11937 | Dep.(mc); $7.60(fs), $2.45(mf) OTS |
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| 3394.1* | 17-11182 | |
| **ASD-TDR–** | **(Non-AEC)** | |

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| 62-214 | 17-11300 | OTS |
| 62-428 | 17-10773 | $2.75(OTS) |
| 62-591 | 17-12033 | $9.10(OTS) |
| 62-756 | 17-11080 | $1.75(OTS) |
| 62-858 | 17-11301 | OTS |
| 62-873 | 17-10579 | OTS |
| **ASD-TR-** | **(Non-AEC)** | |
| 61-150(Pt.II) | 17-11302 | |
| 61-179(Vol.I) | 17-11829 | $0.75(OTS) |
| 886(Vol.VII) | 17-11081 | |
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| 61/62 | 17-11183 | Dep. |
| **BAW-** | **(Misc.)** | |
| 1257 | 17-11938 | Dep.(mc); $4.60(fs), $1.67(mf) OTS |
| **BBC-** | | |
| 113 | 17-11082 | Dep.(mc); $2.60(fs), $1.10(mf) OTS |
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| 101 | 17-11203 | For translation see EURAEC-434 |
| 140 | 17-11253 | Dep.(mc) |
| 147 | 17-12022 | Dep.(mc) |
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| 6155* | 17-10580 | Free(Bureau of Mines) |
| 6157* | 17-10584 | Free(Bureau of Mines) |
| **BMI-** | **(Misc.)** | |
| 1608 | 17-11254 | Dep.; $0.50(OTS) |
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| 6204-01 | 17-10249 | For translation see EURAEC-301 |
| 6204-08 | 17-11108 | For translation see EURAEC-307 |
| 6207-03 | 17-11271 | For translation see EURAEC-410 |
| 6208-15 | 17-11116 | For translation see EURAEC-487 |
| **BNL-** | | |
| 639 | 17-10581 | Dep.; $0.50(OTS) |
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| 767 | 17-11761 | Dep.; $4.00(OTS) |
| 768 | 17-11613 | Dep.; $0.50(OTS) |
| 5838 | 17-11285 | J. Polymer Sci. 62: S141-4(1962) |
| 6042 | 17-11602 | Nucl. Sci. Eng. 14: 339-45(1962) |
| 6044 | 17-11614 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 6082 | 17-11615 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 6083 | 17-11255 | Dep.(mc); $2.60(fs), $0.86(mf) OTS |
| 6094 | 17-11000 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 6095 | 17-11001 | Dep.(mc); $2.60(fs), $0.95(mf) OTS |
| 6097 | 17-10672 | Dep.(mc); $2.60(fs), $0.83(mf) OTS |
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| 6105 | 17-10354 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
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| 6108 | 17-10293 | $2.60(fs), $1.04(mf) OTS |
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| 6148 | 17-10728 | Dep.(mc); $3.60(fs), $1.16(mf) OTS |
| 6162 | 17-10631 | J. Phys. Chem. 67: 201-3(1963) |
| 6166 | 17-11616 | Dep.(mc); $4.60(fs), $1.58(mf) OTS |
| 6174 | 17-10665 | J. Am. Chem. Soc., 85: 14-18(1963) |
| 6188 | 17-10729 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
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| 6388 | 17-11373 | Phys. Letters 2: 292-3(1962) |
| 6397 | 17-11707 | Phys. Rev. 129: 1643-8(1963) |
| 6399 | 17-11709 | Phys. Rev. 129: 1668-72(1962) |
| 6404 | 17-11725 | Phys. Rev. 129: 1809-25(1963) |
| 6437 | 17-10892 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
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| 201 | 17-10581 | See BNL-639 |
| 280 | 17-11063 | See BNL-757 |
| 281 | 17-11184 | See BNL-758 |
| **BRL-** | **(Misc.)** | |
| 1177* | 17-10674 | |
| **CEA-** | **(French)** | |
| 89(M-H) | 17-11797 | See TID-16967 |
| 2172 | 17-11619 | Dep.(mc) |
| 3748 | 17-11118 | For translation see EURAEC-496 |
| **CEA-Bib-** | **(French)** | |
| 29 | 17-10844 | Dep.(mc) |
| **CEA-tr-** | **(French)** | |
| A-1159 | 17-11056 | Dep.(mc); $1.60(fs), $0.80(mf) JCL |
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| 153(Vol.II) | 17-11153 | Dep.; $3.00(OTS) |
| **CERN-** | **(European Organization for Nuclear Research)** | |
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| 62-35 | 17-11064 | Dep.(mc) |
| **CEX-** | | |
| 62.2 | 17-10845 | Dep.; $1.00(OTS) |
| **CISE-R-** | **(Italian)** | |
| 64 | 17-11941 | See EURAEC-475 |
| 65 | 17-11942 | See EURAEC-476 |
| **CNEN-** | **(Italian)** | |
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| **COO-** | | |
| 226 | 17-10294 | Dep.(mc); $10.50(fs), $4.25(mf) OTS |
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| **CRRP-** | **(Canadian)** | |
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| 36 | 17-11786 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
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| 32-62-AEC-1019-Chem. | 17-11624 | See NYO-10386 |

| Report No. | Abstract No. | Availability |
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| 1-82-0166* | 17-11830 | $2.60(OTS) |
| 1-82-0169* | 17-11185 | |
| **DM–** | **(Misc.)** | |
| 62-299 | 17-11999 | For translation see AEC-tr-5610 |
| **DMIC–** | **(Non-AEC)** | |
| 181 | 17-11163 | |
| **DMIC-Memo–** | **(Non-AEC)** | |
| 161 | 17-11083 | |
| **DP–** | | |
| 805 | 17-11979 | Dep.; $1.50(OTS) |
| **DRI–** | **(Misc.)** | |
| 2080* | 17-11186 | |
| **DUBNA REPORTS** | **(Russian)** | |
| See JINR (Russian) | | |
| **EANDC(E)–** | **(European-American Nuclear Data Committee)** | |
| 10.U | 17-11620 | Dep.(mc) |
| **EFINS–** | **(Misc.)** | |
| 62-35 | 17-11521 | |
| **EOS–** | **(Non-AEC)** | |
| 2080-ML-14 | 17-10777 | See NP-12474 |
| **EP–** | **(Misc.)** | |
| 4422-279-63U | 17-11054 | See UVA-279-63U |
| 4422-280-63U | 17-11055 | See UVA-280-63U |
| **ETR–** | **(Belgian)** | |
| 95 | 17-10901 | See NP-12390 |
| **EURAEC–** | | |
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| 437 | 17-11086 | See GEAP-3771-4 |
| 444 | 17-11204 | Dep.(mc); $6.60(fs), $2.06(mf) OTS |
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| 487 | 17-11116 | Dep.(mc); $7.60(fs), $2.48(mf) OTS |
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| 496 | 17-11118 | Dep.(mc); $3.60(fs), $1.16(mf) OTS |
| 499 | 17-11967 | Dep.(mc); $11.00(fs), $4.64(mf) OTS |
| 500 | 17-11943 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
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| 25 | 17-11164 | See EURAEC-412 |
| 29 | 17-11943 | See EURAEC-500 |
| **FZK–** | **(Non-AEC)** | |
| 9-177 | 17-11953 | See NARF-61-45R |
| 9-180 | 17-11262 | See NARF-62-15T |
| 9-183-1 | 17-11900 | See NARF-62-16T |
| 148 | 17-12033 | See ASD-TDR-62-591 |
| **GA–** | **(Misc.)** | |
| 2630 | 17-11981 | Dep.(mc); $4.60(fs), $1.52(mf) OTS |
| 2644 | 17-11849 | Phys. Fluids 6: 276-83(1963) |
| 2985* | 17-10821 | $1.60(ph), $0.80(mf) OTS |
| 3064 | 17-11085 | Dep.(mc); $3.60(fs), $1.28(mf) OTS |
| 3373 | 17-11854 | Phys. Fluids 6: 311-13(1963) |
| **GAMD–** | **(Misc.)** | |
| 2638 | 17-11189 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 3378 | 17-11944 | Dep.(mc); $2.60(fs), $1.07(mf) OTS |
| **GAT-Z–** | | |
| 5035 | 17-10752 | Dep.(mc); $1.10(fs), $0.80(mf) JCL |
| **GDC–** | **(Non-AEC)** | |
| 63-001 | 17-10774 | |
| **GEAP–** | **(Misc.)** | |
| 3771-4 | 17-11086 | Dep.(mc); $4.60(fs), $1.55(mf) OTS |
| 4096 | 17-11945 | Dep.(mc); $7.60(fs), $2.33(mf) OTS |
| 4148 | 17-10792 | Dep.(mc); $2.60(fs), $1.07(mf) OTS |
| **GEMP–** | | |
| 19A | 17-11087 | Dep.; $1.25(OTS) |
| 175 | 17-11982 | Dep.(mc); $8.60(fs), $3.05(mf) OTS |
| **GNE/Phys.–** | **(Non-AEC)** | |
| 62-2 | 17-10856 | See NP-12351 |
| 62-3 | 17-12034 | See NP-12353 |
| 62-4 | 17-11318 | See NP-12357 |
| 62-5 | 17-11320 | See NP-12360 |
| 62-6 | 17-11263 | See NP-12361 |
| 62-9 | 17-11590 | See NP-12368 |
| 62-10 | 17-11006 | See NP-12376 |
| **GNEC–** | | |
| 179 | 17-11165 | Dep.(mc); $7.60(fs), $2.33(mf) OTS |
| **HASL–** | | |
| 120 | 17-10305 | Dep.(mc); $4.60(fs), $1.58(mf) OTS |
| **HW–** | | |
| 61840 | 17-10846 | Dep.(mc); $2.60(fs), $0.86(mf) OTS |
| 69945 | 17-11258 | Dep.; $1.00(OTS) |
| 71521(Rev.) | 17-11259 | Dep.; $0.50(OTS) |
| 72097(Rev.) | 17-10793 | Dep.; $1.00(OTS) |
| 72512 | 17-11003 | Dep.(mc); $2.60(fs), $0.83(mf) OTS |
| 73057 | 17-11088 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 73337 | 17-10847 | Dep.; $4.00(OTS) |
| 73902(Rev.) | 17-10794 | Dep.; $1.60(fs), $0.80(mf) OTS |
| 74712 | 17-12040 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 75228 | 17-11303 | Dep.; $1.50(OTS) |
| 75499 | 17-11304 | Dep.; $1.00(OTS) |
| 75526 | 17-11589 | Dep.; $1.00(OTS) |
| 75746 | 17-10893 | Dep.; $1.00(OTS) |
| 75887 | 17-11458 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |

| Report No. | Abstract No. | Availability |
|---|---|---|
| **HW-SA–** | | |
| 1973 | 17-10582 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 2192 | 17-12041 | $2.60(fs), $1.04(mf) OTS |
| 2419 | 17-11154 | See CEND-153(Vol.II)(p.3-38) |
| 2432(Rev.) | 17-11459 | Dep.(mc); $2.60(fs), $0.86(mf) OTS |
| 2433 | 17-10723 | Dep.(mc); $3.60(fs), $1.13(mf) OTS |
| 2452 | 17-10583 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 2518 | 17-10853 | Dep.(mc); $2.60(fs), $0.83(mf) OTS |
| 2527 | 17-11166 | Dep.(mc); $2.60(fs), $0.92(mf) OTS |
| 2549 | 17-11946 | Dep.(mc); $2.60(fs), $1.01(mf) OTS |
| 2554 | 17-10532 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 2558 | 17-11947 | Dep.(mc); $2.60(fs), $1.01(mf) OTS |
| 2559 | 17-11089 | Dep.(mc); $3.60(fs), $1.25(mf) OTS |
| 2565 | 17-10854 | Dep.(mc); $2.60(fs), $1.04(mf) OTS |
| 2566 | 17-10822 | Dep.(mc); $2.60(fs), $0.89(mf) OTS |
| 2567 | 17-10336 | Health Phys. 8: 747-50(1962) |
| 2577 | 17-10306 | $2.60(fs), $0.95(mf) OTS |
| 2579 | 17-10339 | Health Phys. 8: 761-5(1962) |
| 2584 | 17-11948 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 2589 | 17-10326 | Health Phys. 8: 689-94(1962) |
| 2595 | 17-10499 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 2596 | 17-10585 | Dep.(mc); $3.60(fs), $1.22(mf) OTS |
| 2597 | 17-10586 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 2606 | 17-10359 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 2609 | 17-10855 | Dep.(mc); $2.60(fs), $0.86(mf) OTS |
| 2616 | 17-10894 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 2620 | 17-10731 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 2621 | 17-10587 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 2650 | 17-11260 | Dep.(mc); $3.60(fs), $1.28(mf) OTS |
| 2651 | 17-11004 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 2657 | 17-10533 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| **IA–** | **(Non-AEC)** | |
| 764 | 17-10588 | Dep. |
| 779 | 17-10732 | Dep.(mc) |
| 784 | 17-10534 | Dep.(mc) |
| **IDO–** | | |
| 19311 | 17-11983 | Dep.; $4.00(OTS) |
| 28595 | 17-10795 | Dep.; $2.00(OTS) |
| **IFT–** | **(Polish)** | |
| 1 | 17-11305 | Z. Physik, 171: 34-43(1963) |
| **IHR–** | | |
| 111 | 17-10892 | See BNL-6437 |
| **IKF–** | **(German)** | |
| 1 | 17-12023 | Dep.(mc) |
| 2 | 17-11949 | Dep.(mc) |
| 3 | 17-12024 | Dep.(mc) |
| 4 | 17-11467 | Dep.(mc) |
| 5 | 17-11005 | Dep.(mc) |
| **IS–** | | |
| 385 | 17-10500 | Dep.(mc); $3.60(fs), $1.31(mf) OTS |
| 425 | 17-10675 | Dep.(mc); $2.60(fs), $1.01(mf) OTS |
| 447 | 17-10618 | Ceram. Age 80: 67-70(1962) |
| 458 | 17-10501 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 460 | 17-11090 | Dep.(mc); $2.60(fs), $1.10(mf) OTS |
| 463 | 17-11367 | Phys. Letters, 2: 107-8(1962) |
| 466 | 17-10733 | Dep.(mc); $2.60(fs), $1.01(mf) OTS |
| 473 | 17-11306 | J. Chem. Phys., 38: 425-32(1963) |
| 477 | 17-11190 | Dep.(mc); $2.60(fs), $1.01(mf) OTS |
| 481 | 17-10589 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 487 | 17-10590 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 499 | 17-10591 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 508 | 17-10734 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 520 | 17-10592 | Dep.; $1.25(OTS) |
| 542 | 17-10502 | Dep.; $0.50(OTS) |
| 571 | 17-10796 | Dep.; $0.50(OTS) |
| 583 | 17-10549 | Anal. Chem. 35: 252-3(1963) |
| **JINR–** | **(Russian)** | |
| D-1108 | 17-11468 | Dep.(mc) |
| E-1095 | 17-11905 | Dep.(mc) |
| E-1100 | 17-11469 | Dep.(mc) |
| E-1116 | 17-11470 | Dep.(mc) |
| E-1120 | 17-11471 | Dep.(mc) |
| P-1009 | 17-11307 | Dep.(mc) |
| P-1046 | 17-11472 | Dep.(mc) |
| P-1071 | 17-11473 | Dep.(mc) |
| P-1075 | 17-10735 | Dep.(mc) |
| P-1079 | 17-11474 | Dep.(mc) |
| P-1085 | 17-11475 | Dep.(mc) |
| P-1111 | 17-11476 | Dep.(mc) |
| P-1113 | 17-11308 | Dep.(mc) |
| P-1118 | 17-10535 | Dep.(mc) |
| **JPRS–** | **(Non-AEC)** | |
| 16995 | 17-10870 | $3.60(OTS) |
| 17322 | 17-11119 | $5.60(OTS) |
| **KAPL-M–** | | |
| AA-4 | 17-11132 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| EC-27 | 17-10797 | Dep.(mc); $3.60(fs), $1.25(mf) OTS |
| EC-28 | 17-11950 | Dep.(mc); $2.60(fs), $0.98(mf) OTS |
| HME-6 | 17-11621 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| LXW-1 | 17-10798 | Dep.(mc); $5.60(fs), $1.82(mf) OTS |
| RPC-5 | 17-11951 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **KFK–** | **(German)** | |
| 113 | 17-10895 | Dep.(mc) |
| 115 | 17-11738 | Radiochim. Acta 1: 3-6(1962) |
| 116 | 17-10755 | Chem.-Ing.-Tech. 34: 537-41(1962) |
| **KS–** | | |
| 28 | 17-11328 | See TID-15769 |
| **LA–** | | |
| 2367(Add.) | 17-11065 | Dep.; $0.50(OTS) |
| 2750 | 17-11309 | Dep.; $2.50(OTS) |
| 2806 | 17-11310 | Dep.; $0.75(OTS) |
| 2813 | 17-10593 | Dep.; $0.50(OTS) |
| **LADC–** | | |
| 4814 | 17-10494 | J. Occupational Med. 4: 426-30(1962) |
| 5360 | 17-10338 | Health Phys. 8: 753-60(1962) |
| 5405 | 17-10926 | J. Chem. Education 40: 31(1963) |
| 5422 | 17-11230 | Phys. Letters 2: 165-7(1962) |
| 5493 | 17-11395 | Phys. Rev. 129: 1629-30(1963) |
| 5495 | 17-11391 | Phys. Rev. 129: 1524-5(1963) |
| **LAMS–** | | |
| 2796 | 17-11311 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 2809 | 17-10799 | Dep.; $1.00(OTS) |
| 2814 | 17-11261 | Dep.; $1.00(OTS) |
| 2816 | 17-11831 | Dep.; $0.50(OTS) |
| 2835 | 17-11984 | Dep.; $0.50(OTS) |
| **LF–** | | |
| 5 | 17-10775 | Dep.; $0.50(OTS) |
| **LINAC–** | | |
| 2 | 17-11596 | See TID-15752 |
| 3 | 17-11597 | See TID-16085 |
| **LNF–** | **(Italian)** | |
| 62/94 | 17-11477 | |
| 62/96 | 17-11787 | Dep.(mc) |
| 62/97 | 17-11478 | |
| 62/98 | 17-11479 | Dep.(mc) |

| Report No. | Abstract No. | Availability |
|---|---|---|
| 62/106 | 17-11312 | Dep.(mc) |
| 62/107 | 17-10896 | |
| 62/109 | 17-11480 | Dep.(mc) |
| **MATT–** | | |
| 106 | 17-11832 | Dep.(mc); $2.60(fs), $1.04(mf) OTS |
| 114 | 17-11833 | Dep.(mc); $2.60(fs), $1.01(mf) OTS |
| 119 | 17-11788 | Dep.(mc); $7.60(fs), $2.33(mf) OTS |
| 121 | 17-10897 | Dep.(mc); $3.60(fs), $1.22(mf) OTS |
| 146 | 17-11404 | Phys. Rev. Letters 10: 93-6(1963) |
| **MITS–** | | |
| 49 | 17-11091 | Dep.; $1.00(OTS) |
| **ML–** | (Misc.) | |
| 504 | 17-11798 | See TID-17221 |
| 950 | 17-11838 | See TID-16990 |
| 975* | 17-11449 | |
| **MLM–** | | |
| 1140 | 17-10239 | Dep.; $2.60(fs), $0.95(mf) OTS |
| **MND–** | (Misc.) | |
| 2945-1* | 17-11313 | |
| **MND-M–** | (Misc.) | |
| 3A-2496(Vol.I) (Add.) | 17-11985 | Dep.(mc); $6.60(fs), $2.24(mf) OTS |
| **MSAR–** | (Misc.) | |
| 61-34* | 17-12042 | |
| **N–** | (Misc.) | |
| 62-10115* | 17-10898 | $4.60(ph), $1.49(mf) OTS |
| 62-10371* | 17-10821 | See GA-2985 |
| 62-10900(Pt.III)* | 17-11898 | |
| 62-10900(Pt.IV)* | 17-11899 | $1.60(ph), $0.80(mf) OTS |
| **NAA-SR–** | | |
| 6307 | 17-11986 | Dep.(mc); $9.10(fs), $3.29(mf) OTS |
| 6741 | 17-11316 | Dep.(mc); $3.60(fs), $1.19(mf) OTS |
| 7086 | 17-11952 | Dep.; $1.00(OTS) |
| 7288 | 17-11314 | Dep.; $1.00(OTS) |
| 7511 | 17-10736 | Dep.; $0.50(OTS) |
| 7661 | 17-11315 | Dep.; $1.00(OTS) |
| 7954 | 17-10800 | Dep.; $0.75(OTS) |
| **NAA-SR-Memo–** | | |
| 615 | 17-11092 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **NARF–** | (Non-AEC) | |
| 61-45R | 17-11953 | $13.50(OTS) |
| 62-15T | 17-11262 | |
| 62-16T | 17-11900 | |
| **NASA-TN–** | (Misc.) | |
| D-1685* | 17-11445 | $0.50(OTS) |
| **NBL–** | | |
| 189 | 17-10737 | Dep.; $0.50(OTS) |
| **NDA-Phys.–** | (Non-AEC) | |
| 1349 | 17-11591 | See NP-12370 |
| **NMI–** | (Misc.) | |
| 2112 | 17-11093 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 2113 | 17-11094 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 7254 | 17-11095 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 7256 | 17-11096 | Dep.(mc); $3.60(fs), $1.13(mf) OTS |
| 7257 | 17-11097 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |

| Report No. | Abstract No. | Availability |
|---|---|---|
| **NP–** | (AEC File No. for Non-AEC Reports) | |
| 12208 | 17-10240 | Dep.(mc) |
| 12228 | 17-11167 | Dep.(mc) |
| 12229 | 17-10899 | Dep.(mc) |
| 12231 | 17-10676 | Dep.(mc) |
| 12235 | 17-10677 | Dep.(mc) |
| 12251 | 17-10477 | $9.60(OTS) |
| 12299 | 17-12025 | Dep.(mc); $10.50(fs), $4.37(mf) OTS |
| 12322 | 17-11317 | Dep.(mc) |
| 12324 | 17-10241 | Dep.(mc) |
| 12339 | 17-10242 | |
| 12351 | 17-10856 | $11.50(fs) OTS |
| 12353 | 17-12034 | $10.10(fs) OTS |
| 12357 | 17-11318 | $9.10(fs) OTS |
| 12358 | 17-11319 | |
| 12359 | 17-10503 | |
| 12360 | 17-11320 | $6.60(fs) OTS |
| 12361 | 17-11263 | $6.60(fs) OTS |
| 12363 | 17-10900 | $2.60(ph), $1.04(mf) OTS |
| 12367 | 17-11834 | $1.10(ph), $0.80(mf) OTS |
| 12368 | 17-11590 | Dep.(mc); $8.60(fs) OTS |
| 12370 | 17-11591 | Dep.(mc) |
| 12376 | 17-11006 | $6.60(fs) OTS |
| 12381 | 17-10243 | Dep.(mc) |
| 12388 | 17-11264 | $1.10(ph), $0.80(mf) OTS |
| 12390 | 17-10901 | Dep.(mc); $3.60(fs), $1.22(mf) OTS |
| 12398 | 17-10536 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 12418 | 17-11321 | |
| 12427 | 17-10857 | |
| 12429 | 17-11322 | $3.50(OTS) |
| 12433 | 17-11098 | |
| 12434 | 17-11906 | |
| 12435(Pt.I) | 17-11481 | |
| 12435(Pt.II) | 17-11482 | Dep.(mc) |
| 12436 | 17-11483 | Dep.(mc) |
| 12439 | 17-11622 | Dep.(mc) |
| 12444 | 17-10244 | |
| 12445 | 17-10823 | |
| 12454 | 17-10776 | |
| 12455 | 17-11901 | |
| 12460 | 17-11484 | |
| 12462 | 17-10824 | |
| 12465 | 17-10825 | |
| 12466(Vol.I) | 17-10858 | Dep.(mc); $9.10(fs), $3.29(mf) OTS |
| 12466(Vol.II) | 17-10859 | Dep.(mc); $8.10(fs), $2.81(mf) OTS |
| 12466(Vol.III) | 17-10860 | Dep.(mc); $6.60(fs), $2.30(mf) OTS |
| 12467 | 17-10861 | Dep.(mc); $8.10(fs), $2.72(mf) OTS |
| 12474 | 17-10777 | |
| 12475 | 17-11099 | |
| 12478 | 17-11485 | Phys. Letters, 3: 195-6(1963) |
| 12479 | 17-11486 | Phys. Letters, 3: 175-7(1963) |
| 12480 | 17-11592 | Dep. |
| 12482 | 17-12043 | |
| 12483 | 17-11191 | |
| 12488 | 17-11487 | Dep.(mc) |
| 12492 | 17-12035 | |
| 12493 | 17-11100 | |
| 12496 | 17-11623 | Dep.(mc) |
| 12499 | 17-11488 | Dep.(mc) |
| 12524 | 17-10245 | |
| **NP-tr–** | (AEC File No. for Non-AEC Translations) | |
| 932 | 17-11811 | |
| 941 | 17-10668 | Dep.(mc); $1.60(fs), $0.80(mf) JCL |
| 942 | 17-10669 | Dep.(mc); $1.10(fs), $0.80(mf) JCL |
| 946 | 17-10520 | |
| **NRC–** | (Canadian) | |
| 7096 | 17-11057 | Can. J. Chem. 41: 548-9(1963) |
| **NSL–** | (Non-AEC) | |

| Report No. | Abstract No. | Availability |
|---|---|---|
| 62-212 | 17-12025 | See NP-12299 |
| **NUMEC-P–** | | |
| 49 | 17-11101 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **NYO–** | | |
| 9188 | 17-11323 | Dep.(mc); $2.60(fs), $0.89(mf) OTS |
| 9603 | 17-11324 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 9676 | 17-10902 | Dep.(mc); $5.60(fs), $1.97(mf) OTS |
| 9696 | 17-10504 | Dep.(mc); $5.60(fs), $1.82(mf) OTS |
| 9735 | 17-11102 | Dep.(mc); $4.60(fs), $1.67(mf) OTS |
| 9742 | 17-10778 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 9743 | 17-10779 | Dep.(mc); $2.60(fs), $1.10(mf) OTS |
| 9844-I | 14-11965 | See UNC-5008-I |
| 9859 | 17-10780 | Dep.; $2.75(OTS) |
| 10156 | 17-10698 | See RRL-77 |
| 10251 | 17-11789 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 10284 | 17-11954 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 10327 | 17-11091 | See MITS-49 |
| 10345 | 17-10801 | Dep.(mc); $2.60(fs), $1.04(mf) OTS |
| 10357 | 17-10486 | See TID-15931 |
| 10386 | 17-11624 | Dep.(mc); $6.60(fs), $2.15(mf) OTS |
| **ORA–** | (Misc.) | |
| 03763-10-P | 17-11806 | See TID-17735 |
| **ORNL–** | | |
| 3299 | 17-11192 | Dep.; $2.00(OTS) |
| 3317 | 17-11902 | Dep.; $2.50(OTS) |
| 3320 | 17-10505 | Dep.; $2.75(OTS) |
| 3367 | 17-11489 | Dep.; $0.50(OTS) |
| 3372 | 17-11955 | Dep.; $5.50(OTS) |
| 3374 | 17-10738 | Dep.; $0.75(OTS) |
| 3380 | 17-10515 | Dep.; $1.25(OTS) |
| 3387 | 17-11835 | Dep.; $0.50(OTS) |
| 3394 | 17-11066 | Dep.; $0.75(OTS) |
| **ORNL-TM–** | | |
| 27 | 17-10739 | Dep.(mc); $5.60(fs), $1.91(mf) OTS |
| 181 | 17-10740 | Dep.(mc); $8.60(fs), $2.93(mf) OTS |
| 313 | 17-10741 | $6.60(fs), $2.27(mf) OTS |
| 344 | 17-10903 | Dep.(mc); $4.60(fs), $1.61(mf) OTS |
| 403 | 17-10246 | Dep.(mc); $6.60(fs), $2.09(mf) OTS |
| 430 | 17-11067 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 447 | 17-10742 | Dep.(mc); $2.60(fs), $0.83(mf) OTS |
| 457 | 17-10743 | Dep.(mc); $5.60(fs), $1.79(mf) OTS |
| 475 | 17-10516 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 476 | 17-11987 | Dep.(mc); $6.60(fs), $2.06(mf) OTS |
| **PAN–** | (Polish) | |
| 204 | 17-11625 | Dep. |
| 306/XVII | 17-10678 | Dep.(mc) |
| 336/XIII | 17-10517 | Dep. |
| 354/I-A | 17-11593 | Dep. |
| **PATENTS** | (Czechoslovakian) | |
| 97206 | 17-11824 | |
| **PATENTS** | (German) | |
| 21,852 | 17-11825 | |
| 1,058,479 | 17-11056 | See CEA-tr-A-1159 |
| **PPAD–** | | |
| 459F | 17-11790 | Dep.; $2.50(OTS) |
| 463E | 17-11727 | Phys. Rev. 129: 1866-72(1963) |
| **PUC–** | | |
| 1962-68 | 17-11325 | Dep.(mc); $8.10(fs), $2.87(mf) OTS |
| 1962-89 | 17-11626 | Phys. Rev., 129: 1286-93(1963) |
| **PWAC–** | (Misc.) | |
| 100 | 17-11988 | Dep.(mc); $5.60(fs), $1.97(mf) OTS |
| **Q–** | (Misc.) | |
| A2392-3-6 | 17-10781 | See TID-17311 |
| **R–** | (Misc.) | |
| 228* | 17-11901 | See NP-12455 |
| 2179 | 17-11257 | See EURAEC-464 |
| 3556* | 17-11302 | See ASD-TR-61-150(Pt.II) |
| **RADC-TDR–** | (Misc.) | |
| 62-186* | 17-11836 | $7.60(OTS) |
| **RAI–** | (Misc.) | |
| 303* | 17-10666 | |
| **RC–** | (Misc.) | |
| 180* | 17-11292 | See AD-277043 |
| **RD–** | (Misc.) | |
| 0007 | 17-11989 | See TID-11604 |
| **RED-EPM–** | | |
| 101 | 17-11964 | See TID-17815 |
| 102 | 17-11963 | See TID-17738 |
| 106 | 17-10916 | See TID-17788 |
| **RFP–** | | |
| 290 | 17-10862 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| **RM–** | (Misc.) | |
| 3221-PR* | 17-11490 | $1.60(OTS) |
| **RRL–** | | |
| 77 | 17-10698 | J. Phys. Chem. 67: 11-16(1963) |
| **RSPP–** | (British) | |
| 20(Issue 1) | 17-10863 | Dep.; $0.21(BIS); 1s. 6d. (HMSO) |
| **RT-BIO–** | (Italian) | |
| (62)33 | 17-10349 | Rend. Ist. Lombardo Sci. Lettere B 95: 216-31(1961) |
| (62)51 | 17-10407 | Embryologia(Nagoya) 6: 159-68(1961) |
| **RT-EL–** | (Italian) | |
| 62(14) | 17-11791 | Dep.(mc) |
| (62)15 | 17-11792 | Dep.(mc) |
| **SC–** | (Misc.) | |
| 4747(RR) | 17-11326 | Dep.; $0.75(OTS) |
| **SCDC–** | | |
| 2223X | 17-10906 | See TID-15312 |
| 2575 | 17-10537 | See TID-15724 |
| 2633X | 17-11007 | See TID-15765 |
| 2668 | 17-11267 | See TID-15959 |
| 2682 | 17-11068 | See TID-15948 |
| 2727 | 17-10915 | See TID-17749 |
| 2735 | 17-10539 | See TID-16296 |
| 2968 | 17-10783 | See TID-17773 |
| 3010 | 17-10913 | See TID-17740 |
| **SCL-T–** | | |
| 460 | 17-10921 | Dep.(mc); $1.60(fs), $0.80(mf) JCL |
| **SCPRI(RM)–** | (French) | |
| 62-9 | 17-10864 | Dep.(mc) |
| 62-10 | 17-10865 | Dep.(mc) |
| **SCTM–** | | |
| 100-62-81 | 17-10904 | Dep.(mc); $2.60(fs), $0.83(mf) OTS |

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| 230-62(14) | 17-10905 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| SLAC– | | |
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| 3 | 17-11794 | Dep.; $1.00(OTS) |
| 4 | 17-11795 | Dep.; $0.50(OTS) |
| 6 | 17-11796 | Dep.; $1.00(OTS) |
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| 33/9 | 17-11448 | See BNL-6545 |
| SY– | (Non-AEC) | |
| 5396-R3 | 17-12036 | |
| TID– | | |
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| 7638 | 17-10247 | Dep.; $2.75(OTS) |
| 7646 | 17-12044 | Dep.; $2.25(OTS) |
| 8200(7th Rev.) | 17-11957 | Dep.; Free(DTI Extension) |
| 11601 | 17-11958 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 11604 | 17-11989 | Dep.(mc); $8.10(fs), $2.69(mf) OTS |
| 12268 | 17-10494 | See LADC-4814 |
| 13765 | 17-10744 | $1.10(fs), $0.80(mf) OTS |
| 13790 | 17-10351 | p.499-516 of "Some Aspects of Internal Irradiation." Oxford, Pergamon Press, 1962 |
| 15088 | 17-11627 | Dep.(mc); $3.60(fs), $1.28(mf) OTS |
| 15312 | 17-10906 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 15343 | 17-11051 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 15348 | 17-11052 | Dep.(mc); $2.60(fs), $1.01(mf) OTS |
| 15433 | 17-10667 | Dep.(mc); $2.60(fs), $0.95(mf) OTS |
| 15571 | 17-11595 | Dep.(mc); $3.60(fs), $1.25(mf) OTS |
| 15724 | 17-10537 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 15741 | 17-10594 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 15752 | 17-11596 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 15756 | 17-11168 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 15759 | 17-11327 | Dep.(mc); $2.60(fs), $0.89(mf) OTS |
| 15764 | 17-11053 | Dep.(mc); $2.60(fs), $0.95(mf) OTS |
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| 15769 | 17-11328 | Dep.(mc); $2.60(fs), $0.83(mf) OTS |
| 15770 | 17-10595 | Dep.(mc); $2.60(fs), $0.83(mf) OTS |
| 15773 | 17-10745 | Dep.(mc); $2.60(fs), $0.83(mf) OTS |
| 15774 | 17-11265 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 15779 | 17-11959 | Dep.(mc); $2.60(fs), $0.92(mf) OTS |
| 15792 | 17-10746 | Dep.(mc); $4.60(fs), $1.61(mf) OTS |
| 15793 | 17-10596 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
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| 15796 | 17-10598 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 15849 | 17-11628 | Nucl. Instr. Methods, 17: 225-30(1962) |
| 15850 | 17-10360 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 15852 | 17-10361 | Dep.(mc); $3.60(fs), $1.16(mf) OTS |
| 15860 | 17-10907 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 15865 | 17-10908 | $1.60(fs), $0.80(mf) OTS |
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| 15885 | 17-11907 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 15896 | 17-11266 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
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| 15923 | 17-10747 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 15924 | 17-11630 | Nucl. Phys., 39: 680-5(1962) |
| 15930 | 17-11491 | $1.10(fs), $0.80(mf) OTS |
| 15931 | 17-10486 | Dep.(mc); $2.60(fs), $0.89(mf) OTS |
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| 15935 | 17-10599 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 15939 | 17-10600 | Inorg. Chem., 2: 201-6(1963) |
| 15942 | 17-10601 | Dep.(mc); $3.60(fs), $1.31(mf) OTS |
| 15948 | 17-11068 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
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| 16044 | 17-11492 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 16045 | 17-11330 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 16049 | 17-11631 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
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| 16085 | 17-11597 | Dep.(mc); $2.60(fs), $0.95(mf) OTS |
| 16142(Pt.I) | 17-11960 | Dep.(mc); $7.60(fs), $2.42(mf) OTS |
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| 16174 | 17-11008 | Dep.(mc); $5.60(fs), $1.94(mf) OTS |
| 16175 | 17-11568 | Rev. Mod. Phys. 34: 766-812(1962) |
| 16196 | 17-11711 | Phys. Rev. 129: 1691-1708(1963) |
| 16202 | 17-11632 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 16203 | 17-10886 | $2.60(fs), $1.01(mf) OTS |
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| 16209 | 17-10910 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 16215 | 17-11837 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 16216 | 17-11493 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
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| 16251 | 17-10911 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 16252 | 17-11104 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 16254 | 17-10362 | Dep.(mc); $3.60(fs), $1.25(mf) OTS |
| 16264 | 17-10327 | Health Phys. 8: 695-7(1962) |
| 16278 | 17-11386 | Phys. Rev. 129: 1199-1213(1963) |
| 16295 | 17-10538 | Dep.(mc); $3.60(fs), $1.40(mf) OTS |
| 16296 | 17-10539 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 16304 | 17-11598 | Dep.(mc); $2.60(fs), $0.92(mf) OTS |
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| 16312 | 17-10912 | $1.10(fs), $0.80(mf) OTS |
| 16327 | 17-11024 | Intern. J. Appl. Radiation Isotopes 13: 582-3(1962) |
| 16416 | 17-11932 | Z. Physik 171: 149-70(1963) |
| 16425 | 17-11662 | Nucl. Phys. 39: 408-46(1962) |
| 16517 | 17-11533 | Phys. Rev. 129: 1372-7(1963) |
| 16561 | 17-11133 | Dep.(mc); $2.60(fs), $1.04(mf) OTS |
| 16787 | 17-11922 | Phys. Rev. 129: 1905-10(1963) |
| 16820 | 17-10602 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
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| 16990 | 17-11838 | Dep.(mc); $1.60(fs), $0.83(mf) OTS |
| 16999 | 17-11268 | Dep.; $1.00(OTS) |
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| 17088 | 17-11716 | Phys. Rev. 129: 1728-36(1963) |
| 17095 | 17-11703 | Phys. Rev. 129: 1355-61(1963) |
| 17106 | 17-10653 | Z. Physik 171: 560-81(1963) |
| 17221 | 17-11798 | Dep.(mc); $4.60(fs), $1.58(mf) OTS |
| 17311 | 17-10781 | Dep.(mc); $8.60(fs), $3.11(mf) OTS |
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| 17417 | 17-11719 | Phys. Rev. 129: 1752-3(1963) |
| 17453 | 17-11919 | Phys. Rev. 129: 1876-9(1963) |
| 17468 | 17-11545 | Phys. Rev. 129: 1864-6(1963) |
| 17488 | 17-10753 | Anal. Chem. 35: 224-7(1963) |
| 17522 | 17-10307 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
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| 6209 | 17-10578 | See ANL-FGF-332 |
| 6213 | 17-11327 | See TID-15759 |
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| 6253 | 17-11328 | See TID-15769 |
| 6254 | 17-11265 | See TID-15774 |
| 6256 | 17-10597 | See TID-15795 |
| 6267 | 17-10596 | See TID-15793 |
| 6280 | 17-10814 | See ANL-FGF-335 |
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| 6340 | 17-10577 | See ANL-FGF-292 |
| 6342 | 17-11266 | See TID-15896 |
| 6345 | 17-10999 | See ANL-FGF-340 |
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| 6356 | 17-10679 | See TID-15898 |
| 6372 | 17-10891 | See ANL-FGF-339 |
| 6374 | 17-11180 | See ANL-FGF-337 |
| 6389 | 17-11837 | See TID-16215 |
| 6399 | 17-10910 | See TID-16209 |
| 6400 | 17-11493 | See TID-16216 |
| 6403 | 17-11711 | See TID-16196 |
| 6407 | 17-11079 | See ANL-FGF-334 |
| 6408 | 17-11181 | See ANL-FGF-345 |
| 6413 | 17-11632 | See TID-16202 |
| 6414 | 17-10866 | See TID-16203 |
| 6421 | 17-11009 | See TID-16206 |
| 6477 | 17-11103 | See TID-16243 |
| 6784 | 17-10653 | See TID-17106 |
| 6898 | 17-10753 | See TID-17488 |
| 6910 | 17-11545 | See TID-17468 |
| 6917 | 17-11919 | See TID-17453 |
| 6933 | 17-10574 | See TID-17665 |
| 6934 | 17-10771 | See TID-17615 |
| 6939 | 17-10309 | See TID-17644 |
| 6951 | 17-11444 | See TID-17631 |
| 6952 | 17-11443 | See TID-17779 |
| 6955 | 17-10748 | See TID-17726 |
| 6983 | 17-10802 | See TID-17664 |
| 6998 | 17-11333 | See TID-17640 |
| 7010 | 17-10574 | See TID-17665 |
| 7073 | 17-11461 | See TID-17817 |
| 7084 | 17-11011 | See TID-17824 |
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| 10152 | 17-11196 | $8.10(fs), $2.87(mf) OTS |

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| 10193 | 17-11646 | Phys. Rev., 129: 2659-63(1963) |
| 10197 | 17-10608 | Acta Cryst., 16: 58-62(1963) |
| 10202 | 17-11647 | Dep.(mc); $2.60(fs), $0.89(mf) OTS |
| 10209 | 17-11501 | Dep.(mc); $3.60(fs), $1.40(mf) OTS |
| 10242 | 17-11705 | Phys. Rev. 129: 1601-13(1963) |
| 10265 | 17-11388 | Phys. Rev. 129: 1240-9(1963) |
| 10268 | 17-11726 | Phys. Rev. 129: 1826-34(1963) |
| 10282 | 17-10324 | Health Phys. 8: 665-71(1962) |
| 10312 | 17-11648 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 10343 | 17-11446 | Phys. Rev. 129: 1383-90(1963) |
| 10366 | 17-11839 | Dep.; $1.50(OTS) |
| 10382 | 17-11390 | Phys. Rev. 129: 1258-74(1963) |
| 10406 | 17-11706 | Phys. Rev. 129: 1617-21(1963) |
| 10413 | 17-11713 | Phys. Rev. 129: 1712-15(1963) |
| 10416 | 17-11546 | Phys. Rev. 129: 1889-96(1963) |
| 10435 | 17-11197 | Dep.; $2.00(OTS) |
| 10467 | 17-11542 | Phys. Rev. 129: 1807-8(1963) |
| 10475 | 17-11903 | Dep.; $0.75(OTS) |
| 10481 | 17-11649 | Dep.; $1.75(OTS) |
| 10491 | 17-11073 | Dep.; $0.50(OTS) |
| 10498 | 17-11198 | Dep.(mc); $2.60(fs), $1.10(mf) OTS |
| 10504 | 17-10609 | Dep.; $0.75(OTS) |
| 10505 | 17-10751 | Dep.; $2.75(OTS) |
| 10531 | 17-11650 | Dep.; $2.75(OTS) |
| 10549 | 17-10257 | Dep.(mc); $2.60(fs), $1.04(mf) OTS |
| 10575 | 17-10610 | Dep.; $2.25(OTS) |
| 13059 | 17-11338 | Dep.(mc); $8.60(fs), $2.93(mf) OTS |
| 13061 | 17-11199 | Dep.(mc); $3.60(fs), $1.37(mf) OTS |
| **UCRL-Pub.–** | | |
| 42 | 17-10248 | Dep.; $2.75(OTS) |
| **UCRL-Trans.–** | | |
| 894(L) | 17-10611 | Dep.(mc); $2.60(fs), $0.98(mf) JCL |
| **UNC–** | **(Misc.)** | |
| 5008-I | 17-11965 | Dep.; $3.00(OTS) |
| 5040 | 17-11106 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **USASRDL-TR–** | **(Non-AEC)** | |
| 2257 | 17-11810 | |
| **USNRDL-TR–** | **(Non-AEC)** | |
| 591 | 17-10919 | Dep. |
| 599 | 17-11200 | |
| 601 | 17-10784 | Dep. |
| 602 | 17-10816 | Dep. |
| 604 | 17-11014 | Dep. |
| **UVA–** | | |
| 279-63U | 17-11054 | Dep.(mc); $5.60(fs), $1.79(mf) OTS |
| 280-63U | 17-11055 | Dep.(mc); $2.60(fs), $0.98(mf) OTS |
| **VDIT–** | **(Swedish)** | |
| 50 | 17-11587 | See AE-88 for revision |
| 16(2.4) | 17-11269 | Dep.(mc) |
| **WAPD–** | | |
| 1447 | 17-10920 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 1457 | 17-11599 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 1458 | 17-11502 | Dep.(mc); $3.60(fs), $1.22(mf) OTS |
| **WAPD-PWR–** | | |
| TE-81 | 17-11991 | Dep.(mc); $3.60(fs), $1.25(mf) OTS |
| TE-93 | 17-11992 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **WAPD-T–** | | |
| 1369(Rev.) | 17-11993 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 1370 | 17-11994 | $2.60(fs), $0.92(mf) OTS |
| 1371(Rev.) | 17-11995 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 1448 | 17-11667 | Nucl. Sci. Eng. 14: 358-65(1962) |
| 1455 | 17-11270 | Dep.(mc); $11.00(fs), $4.46(mf) OTS |
| 1490 | 17-11600 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 1507 | 17-11668 | Nucl. Sci. Eng. 14: 366-70(1962) |
| **WCAP–** | **(Misc.)** | |
| 1607* | 17-10804 | Dep.(mc); $2.60(fs), $1.01(mf) OTS |
| 4125 | 17-11996 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 4131 | 17-11997 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **WIS-AEC–** | | |
| 34 | 17-11339 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **XDC–** | | |
| 61-5-2 | 17-11074 | Dep.(mc); $4.60(fs), $1.55(mf) OTS |
| **Y–** | | |
| 1409 | 17-11169 | Dep.; $0.50(OTS) |
| 1410 | 17-10805 | Dep.; $1.50(OTS) |
| **Y-KB–** | | |
| 1 | 17-10311 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 7 | 17-10869 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |